Mathematics Teachers' integration of technology for pedagogical use in a less affluent High School in the Western Cape

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DECLARATION

I, **Addlight Ngonidzashe Buzuzi**, declare that the documents of this thesis represent my own unaided work, and that the thesis has not been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

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ABSTRACT

This study investigates factors that affect the integration of Educational Technology (ET) by mathematics teachers for pedagogy in less affluent high schools in the Western Cape. ET has permeated the education system in the 21st century. It is now a norm for ET to be used in classrooms for educational purposes. Despite the prevalence of a variety of ETs, not all mathematics teachers are fully equipped to take advantage of the immense benefits posited by ET. This study reveals that a lot of mathematics teachers in public schools in the Western Cape still face critical challenges in their attempt to fully integrate ET for pedagogy.

The study employed a qualitative research design to explore the factors affecting the integration and use of ET for curriculum delivery by mathematics teachers in less affluent high schools in the Western Cape Province. The framework underpinning this study is the Technological Pedagogical Content Knowledge (TPACK) framework which guided the researcher in the analysis of the research findings. The researcher used two data collection instruments, namely, semi structured interviews and observations. Face to face semi-structured interviews were conducted with 9 participants and themes were used for analysing data. Participants were fully furnished with information regarding their rights when participating in the study. They were informed that they could withdraw at any given stage during the interview process.

Despite the permeance of technology in the education sphere, the study's findings show that teachers in less affluent schools in the Western Cape still experience mitigating factors that militates against effective integration of technology in classrooms for pedagogy. For effective integration of ET to take place, several factors needed to be critically addressed. They included the lack of training, limited access to ET, lack of technical support, lack of time and the theft of ET resources.

Key words: ET, Integration of ET for pedagogy, less affluent high schools, curriculum delivery

DEDICATION

This thesis is dedicated to my parents, George Buzuzi and Perpertuah Buzuzi, who raised me and made me believe that education is key to success.

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INTRODUCTION TO THE STUDY

1. Introduction

Teachers in developing countries like South Africa are continually being encouraged to integrate educational technology (ET) in their classrooms. These countries are encouraged to find innovative ways to improve curriculum delivery through utilisation of different ET. The driving force behind this stems from the wide range of benefits ET posit like improving curriculum delivery and the quality of education offered (Chigona, 2015). Watson (2015) agrees with Chigona (2015) stating that integration of ET improves curriculum delivery by providing teachers with new ways to address learner needs.

It is therefore imperative that mathematics learners should be exposed to ET to benefit from the advantages that it provides. Looking at the various benefits posited by ET and its ability to empower and transform teaching and learning. The South African government has initiated programmes like the Khanya project. The main aim of the Khanya project is to equip all public schools in the Western Cape with ET (Chigona, 2015). The Khanya project has been training teachers on how to integrate ET in their classes (Chigona, Chigona & Davids, 2014).

The White Paper on e-Education Education (White Paper 7, Section 2.23) of the Department of Education (DoE) (2004) set a goal that by 2013 every teacher and learner should be ICT capable. This goal, though commendable, has proven difficult to realise as the deadline of 2013 has passed yet not every teacher and learner are ICT capable. This boils down to the fact that there is more to integration of ET than merely providing the infrastructure. There is need to understand different facets like teacher beliefs and efficacies regarding what good teaching entails.

According to Stoilescu (2011) the integration of ET is closely associated with teacher beliefs on what is good teaching. Therefore, comprehending the teachers' positions and beliefs on ET is important in understanding the integration of ET in schools. This understanding will aid the achievement of the goals set by the White Paper, that is, the need to have teachers that are ICT capable.

The study focuses on Mathematics because it holds national priority in South Africa. The executive summary of the National Development Plan (NDP) states that one of its core mandates is getting more learners obtaining a minimum 50% for Mathematics (Stols, Ferreira, Pelser, Olivier, Van der Merwe, De Villiers & Venter, 2015). According to Stols et al. (2015) the prevalence of many learners in public schools who receive sub-par mathematics education is a product of the apartheid system and is yet to be fully addressed. Consequently, South Africa is among the worst performing countries in mathematics in the world.

With South Africa experiencing a crisis of under-performing students in mathematics, ET can be harnessed to assist in solving the problem in public high schools in the Western Cape. ET has many advantages when it comes to curriculum delivery. One of the main advantages of ET is its ability to display content in different ways by using diagrams or videos during lesson delivery. This allows for a different perspective to teaching and learning which tends to cater for learners who learn better in the presence of audio-visual material. Thus, ET caters for different learning styles which boost the performance of learners in mathematics.

Furthermore, ET enables learners to become active participants in the teaching and learning process (Chigona, 2015). ET devices such as Interactive Whiteboards (IWB) create learner-centred teaching (Fu (2013). The above points demonstrate the potential ET has in improving learner performances in mathematics classrooms. Against this backdrop, the researcher sought to understand mathematics teachers' integration of ET for pedagogical use in less affluent schools in the Western Cape Province. The interest stems from the potential that ET has regarding the enhancement of learner performance in mathematics. Technologically enhanced learning has vast benefits for the learners.

The proliferation of ET in teaching and learning of mathematics can also be attributed to the fact that the teaching of mathematics in South Africa has been acknowledged as one of the worst on a global scale (Jojo, 2019). In addition, public school in South Africa suffer from poor teaching of mathematics which as a consequence deprives

learners access to higher education and modern knowledge. ET is therefore a tool that can be used to deal with these problems.

The rest of the chapter is organized into the following subsections:

1.1 Significance of the study
1.2 Problem statement
1.3 The aim of the study
1.4 The objectives of the study
1.5 Research questions
1.6 The assumptions of the study
1.7 Explanation of key concepts
1.8 Overview of the chapters
1.9 Summary of the chapter

1.1. Significance of the study

The Department of Education's Draft White Paper on e–Education (2004) posits that the Department values the integration of ET for curriculum delivery to improve the learners' academic performance. The goal is to prepare learners to be useful members of society that are technologically savvy. As this study highlights, the integration of ET is proving difficult as teachers in less affluent high schools in the Western Cape are not integrating ET effectively in their curriculum delivery. Given the many advantages of ET on learner education (Chigona, 2015), there is need to create an environment that encourages ET integration in public schools where mathematics teachers, amongst other subject teachers, start integrating ET in their classes. This position concurs with Nkula and Krauss (2014) who states that despite the numerous opportunities offered by ET there are many schools in South Africa that still experience problems of integration of ET for curriculum delivery.

This study focused on factors affecting the integration of ET in high schools in less affluent areas. These are schools situated in low socio-economic areas and are mostly public schools. Among the challenges they experience is crime and shortage of resources. Because of the sub-par education received by learners in these schools, initiatives such as the Khanya project were created to specifically target

schools in these regions. As noted earlier, the main aim of the Khanya project was to equip all public schools in the Western Cape with ET (Chigona, 2015). The goal was that following the equipping of public schools with ET and training of teachers to utilise ET students in less affluent areas would receive better quality education. The expectation was that ET would bridge the gap caused by lack of resources. Despite this, the concern is that teachers in less affluent high schools are not integrating ET as had been hoped when the Khanya project was launched. This means that learners from these areas continue to receive sub-par education, thereby limiting their chances of being technologically savvy and useful members of society. The aim of this study therefore is to explore ways to increase the chances of getting good quality education for learners through integrating ET for pedagogy in less affluent high schools of the Western Cape. This will go a long way in facilitating their future roles in the economy and society at large.

ET can play a tremendous role in less affluent high schools. It makes teacher planning simpler, enable content to be presented in various ways such as videos or games while it also facilitates learner-centered teaching. All these advantages make it a necessity for teachers in under-resourced schools to use ET in their pedagogy. There are many studies on the adoption of technology in public schools like that of (Stols et al., 2015). This study contributes to such by giving special attention to the Western Cape Province.

The study was designed to gain an understanding on the integration of ET for pedagogical use by mathematics teachers in less affluent areas of the Western Cape Province, South Africa. This was done with the knowledge that teachers received training when the Khanya Project was installing the various ET. This study will help the Department of Education understand why there is such a low uptake of ET for pedagogy in less affluent schools, and subsequently provide solutions on how that can be addressed.

The Technological Pedagogical Content Knowledge (TPACK) theoretical framework underpins this qualitative research project. The TPACK framework was chosen because it aids mathematics teachers to integrate ET in their classrooms (Mishra

and Koehler, 2006). Semi-structured interviews and non-participative observations were used as data collection methods.

1.2 Problem statement

The integration of ET in less affluent high schools in the Western Cape has not been without problems. Mathematics teachers are facing challenges regarding the integration of ET in their classrooms for teaching. Technologies available in these schools include computers, laptops, internet, email, Microsoft office suite, overhead projectors and interactive whiteboards and data projectors. These devices are hailed as potential solutions to the sub-par education being received in public schools. Thus, it is imperative to find out factors that affect their integration into teaching and learning by teachers with particular attention to mathematics classrooms. This is important for the creation of an environment that ensures appropriate teaching and learning. It is important to study the factors affecting the integration of ET in mathematics classrooms to find possible solutions to problems affecting teachers in their integration of ET into their classrooms. This study is of the view that effective integration of ET in mathematics classrooms can improve curriculum delivery and learner performance thereby enabling the goals of the DoE-Draft White Paper on e–Education to be realised. Therefore, the study of teachers and why they integrate ET is crucial to understanding the integration of ET for pedagogical use in mathematics classrooms in the Western Cape Province of South Africa (Marcinkiewicz, 1993).

1.3. The aim of the study

The aim of this study is to establish the factors that affect the integration of ET for pedagogy in mathematics classrooms of less affluent high schools in the Western Cape. The hope is that the findings in this study will be used to help with the integration of ET for pedagogy in mathematics classrooms of other developing countries as well as public schools in the Western Cape and South Africa at large.

1.4. The objective of the study

The objective of this study that emanate from the aim of the study are:

- To identify and analyse the factors that influence the integration of ET for pedagogy in mathematics classrooms of public schools in less affluent high schools.
- To understand challenges that teacher face with the integration of ET for pedagogy in their mathematics classrooms.
- To provide possible recommendations for high schools in less affluent areas of the Western Cape on how to address challenges associated with the integration of ET for pedagogical use in mathematics.

1.5. Research questions

It is important to highlight that integrating ET for curriculum delivery improves the teaching and learning process. Chigona (2015) stated that Integrating ET allow for the transformation of pedagogy and create new ways to access and process information. Despite the countless opportunities that ET bring to teaching and learning, there is a number of factors that constrain the effective integration of ET for pedagogical use. Against this background, the following key research question guided this study:

What are the factors that affect the Integration of ET by mathematics teachers for pedagogy in less affluent High Schools in the Western Cape?

Sub-questions

1. What challenges do mathematics teachers have with the Integration of ET for teaching and learning?
2. What do mathematics teachers perceive as the benefits of using ET for curriculum delivery?

1.6. The assumptions of the study

1. It is the researchers' belief that for effective curriculum delivery to occur in mathematics classrooms there is need for ET to be effectively integrated. This is only fully achievable when the schools are provided with enough support on how to use the ET, and support in case of technical failures.

2. This study rests on the assumption that there is a lack of knowledge on how to integrate ET among mathematics teachers who teach in high schools located in less affluent areas. This consequently creates a problem when it comes to integrating the technology for teaching in the mathematics classrooms. It is vital, therefore, that an ICT committee be formed with qualified personnel to teach teachers on how to effectively use ET and provide support for all technical and related problems, especially in under-resourced and less affluent high schools.

3. The researcher contents that lack of financial resources to acquire, maintain and upgrade ET for pedagogy play a role in constraining teachers ability to integrate ET for pedagogy in their mathematics classrooms. Resource-constrained schools cannot afford ET thereby affecting their capacity to upgrade archaic ET. The effect is that educators are discouraged from integrating ET in their mathematics classrooms.

4. High schools in less affluent areas lack resources to train teachers on how to effectively use ET for curriculum delivery. It is therefore the prerogative of the Western Cape Education Department (WCED) and the school governing body (SGB) to put programs in place to develop teachers to equip them with skills to effectively integrate ET for pedagogy.

1.7. Definition of concepts

The researcher has identified the following concepts as important for this study — ET, Curriculum delivery, Less affluent.

Educational Technology (ET) are technological devices that are used to communicate, create and store information (Meenashki, 2013). For this study ET are devices used to create and communicate information for the purpose of curriculum delivery. This may include, but not limited to, laptops, smart phones, data projectors, interactive whiteboards and the internet.

Curriculum delivery is defined as the many ways learners achieve their intended learning goals. It is the process whereby an educator delivers information and

learners acquire the intended information. It refers to how learners acquire and engage with the intended information they are supposed to learn.

Less affluent refers to areas that are economically disadvantaged. These are areas that are usually inhabited by people from low socio-economic backgrounds. In the context of the Western Cape, these can be schools in the cape flats or township.

Mathematics teachers refers to teachers who are responsible for dispensing information about the subject of mathematics in high schools in less affluent areas of the Western Cape

Integration of technology refers to the process whereby technology is used in the classroom for curriculum delivery.

High school refers to the level of schooling learners who have completed primary education go to. Usually for learners from the age of 13 up to 19.

Pedagogy refers to the teaching, teaching style or teaching method.

1.8. Overview of chapters

This section presents a summary of the different chapters that make up this study. The following is a brief narrative of the five chapters.

1. **Chapter 1**: Provides the background, aims, objectives and a description of the research question guiding the study. The background has been provided from a general perspective with focus on the adoption of ET in less affluent high schools in the Western Cape. The key concepts used in this study are clearly defined in this chapter.
2. **Chapter 2**: Reviews literature on the integration of ET in high schools in less affluent high schools. Focus is on explaining how crucial ET is in education, problems faced by teachers in integrating ET for pedagogy, and barriers in using ET. The theoretical framework that underpins this study is also explained.
3. **Chapter 3**: Discusses the research design and methodology used in this qualitative study. The chapter also justifies the choices used in this study with regards to research methods. Details of sampling procedures,

methods of data collection and concerns of trustworthiness, reflexivity and ethical considerations are also clarified in detail.

4. **Chapter 4**: Presents the main themes and findings that emerged during analysis. Themes dealing with the integration of ET for pedagogy in less affluent high schools in the Western Cape are explored. The findings are linked with the theoretical framework that guides this study.
5. **Chapter 5**: It presents the conclusion and recommendations. Findings are blended to determine the impact of integrating ET for pedagogy in less affluent high schools in the Western Cape.

1.9. Summary of the chapter

The research study has been introduced in this Chapter. The research problem and research questions have been clarified. The emphasis has been on the need to investigate the factors affecting the integration of ET for pedagogy in a mathematics classroom of a less affluent high school in the Western Cape.

The next chapter reviews the relevant literature in detail.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1. Introduction

It was mentioned in the preceding chapter that this study aims to establish factors that that affect the integration of ET for pedagogy in a mathematics classroom for high schools that are located in less affluent areas of the Western Cape. As such, it is vital to analyse previous studies focusing on the integration of ET. This must happen in order to broaden understanding of issues related to the integration of ET. Chapter 2, therefore, focuses on reviewing literature that deals in depth with issues regarding the integration of ET for pedagogy in schools.

The literature review was undertaken to find a credible framework that can underpin this study. Mathematics has been used as a subject of focus since it is a national priority in South Africa. The executive summary of the National Development Plan (NDP) states that one of its core mandates is getting more learners obtaining a minimum 50% for Mathematics (Stols, et al., 2015). As such the researcher opted for mathematics as a subject of reference given its priority position in the South African education system

The rest of this chapter is structured as follows:

2.1 Introduction
2.2 The importance of integrating Educational Technology in classrooms
2.2.1 The importance of integrating Educational Technology in mathematics classrooms
2.3 Integration of Educational Technology in less affluent schools
2.4. Barriers to integrating Educational Technology.
2.4.1. Teacher attitudes and beliefs on the integration of ET (Internal Barriers)

2.4.1.1. Teacher self-efficacy

2.4.1.2 Gender

For optimum Integration of emerging ET or ICTs in classrooms there is a need to reflect on ongoing classroom practices. The TPACK framework is paramount to effective ET integration in mathematics classrooms. With various ET constantly permeating our society, many schools have begun integrating the technologies into their curriculum delivery due to the potential advantages they present. For optimum integration of ET like interactive white boards (IWB) and computers there is need to understand factors that encourage or inhibit their integration of various ET in mathematics classrooms. As will be shown in this study, TPACK entails a spectrum of pedagogical approaches neatly interwoven with appropriate technological understanding for pedagogy to be executed effectively.

We are now living in an era where our daily lives are intertwined with technology. For instance, internet users have more than doubled in the 5 years between 2009 and 2012 with numbers projected to have moved from 0.974 billion to 1.9 billion (Stols, et al., 2015). Additionally, the rapid social and political changes in many developing economies like South Africa created economies demanding the use of technology in life and for teaching subjects like mathematics. It is therefore important to understand factors behind ET integration so that an environment that caters for ET integration in mathematics classrooms is created.

2.2. The importance of integrating Educational Technology in classrooms

Berry (2013) states that teachers need to come "to an understanding that ET has power to both advance innovation and collaboration or mislead and distort, and it is the classroom teacher/facilitator's responsibility to foster the realization of the power of ET" and its use in and around the classroom. The power of ET inside the classroom includes its ability to elevate students' creativity, innovation and critical thinking as well as adept researchers and problem solvers (Watson, 2015).

Tondeur, Valcke, and van Braak (2008) posit that the widespread technocentric view about the transformative nature of ET has resulted in the introduction of various ET's in schools. For them ET's are seen as powerful tools for supporting learner centred environments. Concurrently, they provide access to resources that enable the construction of personal meaning by providing interlinks between new knowledge and existent knowledge. The provision of such interlinks provides learners with a superior learning environment. According to (Fu, 2013) ET's intrinsic ability to transform teaching and learning by increasing learner engagement creates a superior learning environment. When ET's are effectively used learner performance on assessments increases. The innate ability of ET to improve learner performance lies in the fact that it houses facilities like videos and audio's that offer better learning opportunities compared to static media. ET provides opportunities for lively interactions and inquiries (Kaput & Shaffer, 1999 cited in Stoilescu, 2011). Furthermore, ET has new representational infrastructures that provide openings to reintegrate knowledge previously learnt.

Murcia (2010) argued that ET initiates a means for the development of interaction and dialogue among learners. The two emanate from the inherent nature of ET to create a learner-centred teaching environment. A learner-centred teaching environment allows for the creation of an environment where learners are subjected to working together during activities like group work, and by so doing facilitating dialogue and interaction. Warwick, Mercer, Kershner & Staarman (2010) concurs with the above asserting that ET provides an instrument and environment that encourages dialogue and knowledge construction among learners.

Hall & Higgins (2005) found out that both teachers and learners reported that ET use in education made lessons enjoyable. Consequently, that attribute of ET has led to the proliferation of various ET such as computers and the internet in classrooms around the world (Hsu, 2010). For Somyürek, Atasoy & Özdemir (2009) and Higgins (2003) ET has become widespread because its incorporation in the classroom raises teaching and learning to new levels. Bester and Brand (2013) concur with Somyürek et al. (2009) and Higgins (2003), arguing that integrating ET encourages learner-centred learning and provide teachers with options to develop skills like comprehension and problem solving in their learners.

Watson (2015) is of the opinion that technological features such as photos, sound, animations and video are elements that encourages learners to learn, and in the same vain enhance teaching by capturing and maintaining leaner concentration. Their point is that visual learners benefit from good visual resources like pictures and videos. In light of this, ET like Interactive Whiteboards enable lively, exhilarating lessons, drawing from videos and animations from different sources. Chigona (2015), in support of points by Watson (2015), stated that ET enable learners to experience real world scenarios. Furthermore, educationalists believe that ET help students to measure up to challenges in the fast-changing world. An example of this is the learners' need to learn how to think critically and seek information (Tondeur et al., 2008) using various technological devices like computers and the internet. So, with various ET like the Interactive Whiteboard (IWB) and the internet, teachers are finding various ways to make lessons creative and exciting for the learners (Watson, 2015).

Chigona (2015) is of the opinion that integrating ET allows for the transformation of pedagogy. The view is that ET allow for new ways to access and process information. Its flexibility enables learners to work at their own pace. Tondeur et al. (2008) agrees with Chigona (2015) asserting that ET supports constructivist pedagogy and the creation of an environment that empowers learners to take charge of their own learning. Collins and Halverson (2009) describe a shift where learning has moved from a mere memorisation of information to a situation where learners more readily use critical thinking and different resources to analyse information. In order to assist learners, think critically, ET has been integrated as a resource into the

education system. Throughout the years the integration of ET has changed vastly from using overhead projectors which utilise transparencies to Interactive Whiteboards (Ramey, 2012). Different technological resources are frequently introduced to the classroom — examples being Interactive Whiteboards, tablets, Geogebra, Maple, Geometer's Sketch Pad, screen casting tools, pencasts, podcasts, etc (Ramey, 2012). According to Lin, Hsu & Yeh (2011) the innumerable number of ET available to learners allow them to collect and present data easily.

For Engel and Green (2011) technological devices like cell phones which allow learners to give answers anonymously provide situations for deeper understanding of a topic. Teachers, therefore, can integrate devices like cell phones that allow for anonymity to check learner understanding and how they reflect on their work. Bray and Tagney (2015:175), when illustrating the importance of utilising various ET like mobile tools, posited that "The use of mobile devices can permit the traditional concept of the classroom to be expanded to include the environment and wider community. Data can be realistic and activities genuinely problem-solving, and the potential for sharing data and the social construction of meaning across multiple contexts open exciting possibilities for collaborative learning. Thus, the use of mobile ET has the potential to have a transformative impact on task design." Engel and Green (2011) noted that ET like mobile phones, which provide anonymity, can help learners who are usually embarrassed to answer questions for fear of getting answers wrong. Anonymity give students the confidence to check their understanding by answering questions. Therefore, anonymity allow learners that are typically shy to engage with information and get timeous accurate feedback from the teacher.

Also, learner performance on assessments can increase through effective use of ET. The innate ability of ET to improve learner performance lies in the fact that ET houses facilities like videos and audio's that offer better learning opportunities as compared to static media by providing opportunities for lively interactions and inquiries (Kaput & Shaffer, 1999 cited in Stoilescu, 2011). Furthermore, ET has new representational infrastructures that provide openings to reintegrate knowledge previously learnt.

2.2.1 The importance of integrating Educational Technology in mathematics classrooms

The Integration of ET in the education system emanate from the fact that ET enhance and facilitate curricula (Leendertz, Blignaut, Nieuwoudt, Els, and Ellis, 2013).ET has the power to meet mathematical curriculum objectives. It provides novel ways of performing calculations efficiently, and to the specified degree of precision (Leendertz et al., 2013). Baglama et al. (2017) agrees with Leendertz et al. (2013) regarding the significance of educational technology in mathematics classrooms. They argue that recent trends on ET integration are encouraged in education due to the vast benefits they present.

ET are tools that are constitutive components of the education situations in which students' function (Urban-Woldron, 2013). They offer chances for mathematical laboratory inside classrooms. ET also allow for rapid provision of feedback while supporting learner engagement and knowledge construction in investigative activities (Urban-Woldron, 2013. These investigations are made exciting, relevant and challenging to learners by the appropriate usage of ET (Urban-Woldron, 2013). Additionally, ET help learners increase basic mathematics skills by creating more opportunities for engagement (National Council of Teachers of Mathematics, 2011).

The National Council of Teachers of Mathematics (NCTM, 2008) asserted that "with guidance from effective mathematics teachers, learners at different levels can use technology to support and extend mathematical reasoning and sense making, gain access to mathematical content and problem-solving contexts, and enhance computational fluency." It is also important to note that ET enables educators to use various techniques and tools in mathematics education to enhance learner learning. Mathematics is a subject that is regarded as difficult by many due to mathematics anxiety. However, using ET for teaching mathematics provide learners with different ways and methods of learning the subject in a relaxed and fun environment thereby removing the 'mathematics is difficult mindset'. As postulated by House and Telese (2011), learners who normally use ET for school-related activities enjoy the study of mathematics. They continue to aver that learner's interest in a subject is spiked up if

they like the introduction, which can be facilitated through appropriate and effective usage of ET for pedagogy.

In spite of ETs potential for curriculum delivery, its integration into high school mathematics has not met the expectations that researchers of decades prior had (Drijvers, Doorman, Boon, Reed, & Gravemeijer, 2010). There are many reasons for this phenomenon. These include teachers not perceiving the use of ET as valuable for the teaching of mathematics. As such teachers avoid integrating ET unless the institutions, they work for force them to (Drijvers et al., 2010). They further assert that the best way to get teachers to integrate ET into their mathematics classrooms is for new teaching techniques to be developed. These new techniques have to be related to techniques already existing and they must also be linked to teachers views on mathematics education (Pierce & Ball, 2009).

Garofalo, Drier, Harper, Timmerman, and Shockey (2000:67) give guidelines on how to integrate ET in a mathematics classroom. They suggested the following steps: “introduce ET in context, address worthwhile mathematics with appropriate pedagogy, take advantage of ET, connect mathematics concepts, and incorporate multiple representations.” Integrating ET helps learners to move from procedural thinking to conceptual thinking which promotes problem solving and critical thinking (Kaput et al., 2007). ET allows mathematics teaching and learning to evolve to a new level that is highly visual and interactive (Kaput et al., 2007). Zbiek et al. (2007) agrees with Kaput et al. (2007) arguing that ET provides opportunities for learners to experience concrete mathematical activities which afford them a chance to enrich their mathematical thinking and understanding. This is achieved as learners are able to explore different approaches to learning mathematics.

When coupled with a suitable pedagogical framework, Bray and Tagney (2015) are of the view that the use of ET like mobile technology can make the learning of mathematics more meaningful, practical and engaging. Teachers need to know how to utilise ET with appropriate pedagogy to make mathematics learning more practical for learners. Consequently, it is important to train teachers for effective use of ET for pedagogy (Stoilescu, 2011). Educating teachers on how to effectively integrate ET

for pedagogy avoids situations whereby teachers use ET senselessly as a panacea for improving curriculum delivery (Stoilescu, 2011).

The Ontario Ministry of Education (2007) made the following recommendations on how ET must be integrated in mathematics classrooms. It stated that teachers should use ET in the following ways:

- "Communicate and exchange opinions in classrooms, from home and with other classrooms and schools;
- Locate, disseminate, and access different internet resources;
- Use databases, spread sheets, word processing, presentations, and multimedia documents;
- Manipulate large quantitative data, reduce the time for routine mathematical tasks allowing students more time to think for conceptualisations and designing solutions;
- Use graphical software, computer algebra systems (CAS), statistical software; and
- Practice simulations and computer-assisted learning modules for supporting mathematical inquiry."

Bray and Tagney (2015:175) agrees with the above noting that there should be communication in and out of the classroom. They stated that "The use of mobile devices can permit the traditional concept of the classroom to be expanded to include the environment and wider community. Data can be realistic and activities genuinely problem-solving and the potential for sharing data and the social construction of meaning across multiple contexts open exciting possibilities for collaborative learning. Thus, the use of mobile ET has the potential to have a transformative impact on task design." ET facilitates for pedagogy to happen outside the four walls of the classroom, allowing for learning to be realistic and to happen in the real world. When all this happens, learners are able to produce visualisations, explorations and connect dynamic notations which help learners to comprehend mathematics better while improving their performance in the subject (Kaput & Shaffer, 1999 cited in Stoilescu, 2011).

Educational technological tools provide a wide range of benefits which assist learners in the mathematics classroom. Baglama et al. (2017) noted that including a variety of technological tools in the teaching of mathematics teachers can enhance the performance of students who have various types of disabilities. Therefore, technological integration can be used to assist learners with special needs.

Et integration has been seen to help with special needs learners to acquire various mathematical skills. Baglama et al. (2017) aver that mathematics skills are one of the most critical skills that learners with special needs need to attain so as to maintain order in their day to day livelihood. Integrating ET into special education classrooms is necessary in order to increase achievement for individuals with special needs. It is therefore a necessity that teachers be competent in using ET in teaching mathematics so as to better aid learners to increase their achievements in mathematics (Baglama et al., 2017).

2.3 Integration of Educational Technology in less affluent schools

Nkula and Krauss (2014) posit that despite the opportunities offered by ET, many schools in developing countries such as South Africa do not have access to it. This means that learners from poor, less affluent areas are losing out on the opportunities offered by the integration of ET in pedagogy. The fortunate few tend to utilise ET in a limited manner by focusing mainly on learning about computers or acquiring ICT skills instead of having technology as an integral part of curriculum delivery (Nkula & Krauss, 2014).

In many developing countries like South Africa, students learn about computers rather than through computers. Consequently, ET is implemented *without* integration. Implementation *with* integration is a situation where students utilise ET to learn, with ET an integral part of curriculum delivery (Nkula & Krauss, 2014). Wilson-Strydom and Thompson (2005) aver that implementation without integration is the acquisition of the technical skills and learning about computers whereas implementation *with* integration is learning *through* or using a computer. There is need therefore to have ET be an integral part of the lessons, where learners use ET devices to learn and help grasp concepts. This has the potential to aid learners improve their performance in mathematics.

The South African White paper on e-Education observed that the integration of ET in South African schools for curriculum delivery is one of the biggest challenges (Nkula & Krauss, 2014). Generative use of ET, which is implementation of ET with integration, is not prevalent in South African schools. Many teachers lack the necessary skills required to successfully integrate ET into curriculum delivery. For Unwin (2005), this problem is found right across Africa and in many developing countries. Teachers lack the skills necessary for effective of integration of ET for curriculum delivery which results in ET often being used on special occasions. As a result, ET remain an object of curiosity, fear, uncertainty, and mystery rather than an enabling tool (Pelgrum, 2001; Unwin, 2005).

One of the barriers that make ET integration difficult in less affluent areas is unreliable electricity supply. Other factors include time constraints. Teaching is a

demanding profession. Thus, time to prepare for lessons, including ET, isn't readily available (Stols et al.,2015). This is further compounded if the teacher is not very comfortable with utilising ET. In addition, there is a burden of connecting the technological devices every morning which in itself takes time from the ongoing lesson. Voogt and Tondeur (2015) highlighted the lack of infrastructure, financial problems, connectivity problems and appropriate training for teachers as some of the problems affecting teachers in less affluent areas when it comes to integration of ET. There is a shortage of resources to effectively deliver training to teachers. According to Stols et al. (2015) many teachers lack time. They view ET as a tool that will consume time they do not have. Because of this, many teachers have negative views on the integration of ET into their classes.

One of the key failures of programmes in African countries is the lack of support for teacher's professional development despite schools being provided with technological devices (Voogt and Tondeur, 2015). It is therefore evident that technological integration is not just about the placement of hardware and/or software. Rather, it encompasses other aspects such as teacher professional development (Tondeur, Cooper, & Newhouse, 2010).

Mentz and Mentz (2003) are of the opinion that the main reason behind the poor integration of ET in public schools in South Africa are the following, in order of importance:

- Inadequate financial funding from the Department of Education;
- Teachers who lack formal training;
- Absence of electricity;
- Absence of proper security which culminates in theft and vandalism;
- Curriculum restrictions ("where do we fit computer education into an already tight curriculum?").
- Skewed teacher: learner ratio (typically more than 1:30.

Apart from giving schools technological devices, government must ensure that the ET is utilised rather than lying idle. For Ndlovu and Lawrence (2012), there is need for teacher training that properly equips teachers to use ET. Their emphasis is on the importance of training surrounding the Technological Pedagogical Content

Knowledge (TPCK) because it encourages an efficient integration of ET for curriculum delivery. Barriers to integrating Educational Technology

There are a variety of barriers that impede teachers' efforts to successfully integrate ET into their pedagogy. A barrier, according to Schoepp (2005:14), is an ailment that makes it problematic to make headway or accomplish an objective. According to Ertmer (1999), there are two barriers to teachers integrating ET into their classrooms. They list these barriers as external (first order) and internal barriers (second order). External barriers are those that are related access to ET, training on how to use these ET and availability of support. They include insufficient time, lack of access, insufficient money, and lack of training, unreliable supply of electricity, the burden of connecting the ET at the start of every period and time constraints for preparation and teaching (Salehi and Salehi, 2012; Stols et al., 2015). The authors stated that the presence of these barriers make it impossible to even consider the integration of ET. It has been documented that resolving first order barriers does not automatically translate to teachers using ET in their classrooms (Ertmer, 1999). Tondeur et al. (2008, citing Ertmer, 1999) aver that it is important to look at second order barriers which relate to teachers' philosophy on curriculum delivery as this has an influence on how the teachers goes about teaching their classes.

2.4.1. Teacher attitudes and beliefs on the integration of ET (Internal Barriers)

In order to have full ET Integration in schools it is important to understand teachers' attitudes and have teacher support programmes (Buabeng-Andoh, 2012). Buabeng-Andoh argued that a teacher's openness to integrate ET is largely based on his/her attitude towards ET and its usefulness. These sentiments are largely shared by many researchers such as Polly & Hannifin (2010) who posit that as we aim to increase ET integration in teaching it is important to consider the teachers' role. They are of the opinion that teacher's attitude a determining role in the integration of ET in the class.

Empirical studies show that educational belief has an impact on the regularity at which a teacher uses ET in their classroom (Tondeur et al., 2008). Tondeur et al. (2008) states that a teacher's attitude toward integration of ET is related to his/her

experience with different ET like computers. Neyland (2011) affirms that teachers' attitude towards ET has a bearing on their integration of ET. This concurs with Tondeur et al. (2008) who posited that a teacher's attitude towards ET influences the integration of ET. For Buabeng-Andoh (2012), if teachers do not perceive ET to be useful to curriculum delivery, they will not integrate it into their classrooms. Thus, it is important for teachers to have a positive attitude towards the use of ET if there is to be a huge uptake of ET integration in schools.

Chigona and Chigona (2010) are of the opinion that some teachers do not integrate ET in their classes because they are computer-phobic. Buabeng-Andoh (2012) extends this point stating that teachers in Portugal said that it was the absence of fear of damaging ICT and their ability to have absolute control over computers that encouraged them to integrate ET in their classrooms. Chigona and Chigona (2010) further noted that some of the reasons why teachers do not integrate ET are psychological. An example of this is having a feeling that one may damage a computer. If teachers have fear of breaking computers, they will not integrate the technology. This means that fear in the affected teachers must be dealt with to avoid installing ET and training of teachers without results.

According to Leendertz (2013) the role ET plays in a classroom is strongly linked with teachers' belief on the nature of teaching and learning. Buabeng-Andoh (2012) supported this stating that teacher belief about the nature of education dictates if, and how ET will be integrated into the classroom. Leendertz (2013) argued that to fully understand ET integration teachers' pedagogical beliefs should be taken into account. Marcinkiewicz (1993) concurs with this positing that there is a need to study teachers and understand what makes them integrate technology, if we are to get full ET integration. In addition, Leendertz (2013) points out that teachers who hold constructivists beliefs on teaching integrate ET more readily than teachers who hold teacher-centered beliefs. Furthermore, he argued that teachers who hold constructivist beliefs use ET in a learner-centered way that encourages students to develop higher-order thinking and problem-solving skills.

2.4.1.1. Teacher self- efficacy

Teacher self-efficacy was an influencing factor in the Integration of ET. Buabeng-Andoh (2012) stated that teacher's self-efficacy has been reported to have a great influence on the integration of ET. Bandura (1997) defined self-efficacy as one's confidence to perform an activity in order to attain a task. Thus, ET self-efficacy can be defined as a teacher's confidence in using ET. Leendertz (2013) agrees with this point stating that lack of confidence is a barrier to ET integration in mathematics classrooms.

Chigona (2015) agrees with Tondeur et al. (2008), Buabeng-Andoh (2012) and Leendertz (2013) arguing that teacher efficacy influences whether teachers integrate ET in their classes. She further adds that teacher efficacy influences teachers' technological efficacy. Chigona concludes that if a teacher was never trained to use ET it would impact their teaching, and subsequently generates low self-efficacy to integrate ET into the classroom. A teacher with a positive self-efficacy will feel confident enough to be innovative and creative in the classroom (Chigona, 2015). Therefore, boosting the confidence of mathematics teachers will result in the teachers becoming enthusiastic and more interested towards embracing ET in curriculum delivery (Leendertz, 2013).

2.4.1.2 Gender

Gender has been noted as an influencer on the integration of ET, with more males more prone to integrate ET as opposed to their female counterparts (Tondeur et al., 2008). Buabeng-Andoh (2012) shares the same view, asserting that there are few studies that show that female teachers integrate ET at low levels as compared to their male counterparts due to factors like limited ET access and limited interest. On the contrary, Breisser (2006)'s findings observed that female perceptions on the usefulness of ET had improved while male perceptions had remained unchanged. This trend was confirmed by Yukselturk and Bulut (2009) who noted more females as using ET like the internet at a more frequent rate compared to their male counterparts.

2.4.2. External barriers to the integration of ET for pedagogy

In developing countries like South Africa external factors play a big role in determining the integration of ET for pedagogy. External factors such as unreliable electricity supply and time constraints are affecting teachers' integration of ET. The lack of time to prepare for lessons that include the use of ET is another factor (Stols et al., 2015). Other external factors include the absence of support from the schools when it comes to matters that deal with integrating ET in the classroom (Neyland, 2011). Against this backdrop Buabeng-Andoh (2012) argued that in order to have successful integration of ET institutions must have strong school programs that offer support to teachers. External barriers will be listed and discussed in more detail below.

2.4.2.1 Teacher training

Teacher beliefs on the usefulness of ET may be formed during teacher training, and as such Baylor and Ritchie (2002) aver that ICT training influences the integration of ET in the classroom. For Casey (2010), teachers are not integrating ET in their classes because they believe they were not adequately trained. Felicetti (2011, 2) added that the experience of teachers with ET as learners shape how the teachers will integrate ET once qualified as teachers.

In their study on ICT integration in Western Cape schools, Chigona and Chigona (2010) noted that few teachers were incorporating ET in their classes despite having received training through the Khanya project. They observed that teachers were still uncomfortable utilising ET in their classes, signifying that the training they received was inadequate. This concurs with the findings of Casey (2010) and Felicetti (2011, 2) who argued that teachers are not integrating ET in their classes because they feel inadequately trained.

2.4.2.2 Technical Support

Chigona and Chigona (2010) also discovered that teachers who were supposed to be using ET did not have enough technical support to help them in their integration. When teachers needed technical help, the technicians delayed coming leaving

teachers waiting for them to show up (Chigona and Chigona, 2010). This affected teacher's enthusiasm in integrating ET. Hayes (2005) argued that there was need for Principals to provide support to teachers by putting measures for professional development in place. He continues to state that it is important to offer support to teachers, and to also have structures such as ICT plans and ICT training (Hayes, 2005).

2.4.2.3 Teaching experience

The amount of time a teacher has been teaching was found to influence ET integration. According to the U.S National Centre for Education Statistics (2000), teachers who have taught for about 3 years used computers 48% of the time compared to teachers with between 4- and 9-years' experience who used computers 45% of the time. Additionally, teachers who had more than 10 years teaching experience utilised computers 47% of their time with those with more than 20 years' experience utilising computers 33% of the time (U.S National Centre for Education Statistics, 2000). A possible reason for this trend could be that newly qualified teachers are more acquainted with the use of ET.

The findings of Buabeng-Andoh (2012 citing Lau & Sim, 2008), in their study in Malaysia contradict those of the U.S National Centre for Education Statistics (2000). Their findings showed that younger teachers were integrating ET less compared to their experienced counterparts. The reason provided to explain this phenomenon was that older teachers have more experience with curriculum delivery and classroom management, and over time become competent with integrating ET. Chigona (2015) is of the opinion that while new qualified teachers are expected to integrate ET anecdotal evidence shows that not many are incorporating ET into their classes due to poor training from their teacher education. This then means that teachers are qualifying without the specialised skill needed to incorporate ET into their classrooms.

2.4.2.4 Workload

Teachers have many classes to cater to, and the demand of the large workload discourages the integration of ET due to a lack of time (Leendertz, 2013; Stols et al., 2015). Leendertz (2013) noted that large numbers of students in classrooms keep teachers so busy, so much so that embracing of ET is seen as posing a risk of increasing work demands.

2.4.2.5 Possible solutions to barriers of integrating ET in less affluent schools

Dexter, Anderson and Becker (1999) claim that there has to be an agreement on various levels for the successful integration of ET to happen. The different levels are described by Balanskat, Blamire & Kefala (2006) as teacher-level, school-level and system-level. It is imperative that educators share similar values as the school policy on the integration of ET in the class (Kennewell, Parkinson, & Tanner, 2000). Otto and Albion (2002) agrees with the aforementioned authors stating that it is important to have a shared vision on how ET should be integrated. An assessment and evaluation approach is needed for the ET integration plan to be developed, clearly showing how the ET will be used (Kennewell et al., 2000).

Tondeur et al. (2016) suggested that schools with structures like policy planning, ET support and peer support have a positive effect towards teachers integrating ET in their classrooms. In agreement, Hayes (2005) found that the involvement of the principal help to encourage teachers to integrate ET in their classes, more so when the integration process is closely related to the school's vision for learning. The expectation is that the Principal provide support to teachers by putting in place measures for professional development (Hayes, 2005). Tondeur et al. (2016) added to this saying that peer support reinforces teacher beliefs and the sharing of ideas among them regarding how to use ET to support student-centred teaching. It is interesting to note that learners' negative attitudes and poor technological skills deter student-centred ET integration (Tondeur, et al., 2016).

Chigona (2015:244) argued that "even though most of teacher education learners have the technical skills to operate ET, they still lack the technological pedagogical

content knowledge which is necessary for one to be able to appropriate ICTs into curriculum delivery." Empirical data confirms that educators lack information (TPACK) on how to integrate ET in their classrooms for curriculum delivery (Koehler, Mishra, Akcaoglu, & Rosenberg, 2013). To increase ET integration into the classroom, adequate professional development is required (Glazer, Hannifin & Song, 2005).

2.4.2.6 WCED technology integration initiative

Many ICT related projects have been initiated in South Africa. The initiatives are meant to ensure that schools gain access to technology. For this study we will focus mainly on the Khanya project as it was initiated specifically targeted at public schools in the Western Cape. The Khanya project was established in April 2001, and had the following objectives:

- ✓ Increase educator capacity and effectiveness by means of technology;
- ✓ Harness the power of technology to deliver the curriculum,
- ✓ Enhance the quality of the learning experience in the classroom, providing an opportunity for students to benefit from a variety of learning styles;
- ✓ Integrate appropriate and available technology into the curriculum delivery process as different technologies mature;
- ✓ Use technology to assist all disabled students to maximise learning;
- ✓ Improve Senior Certificate and FET results, as well as student outcomes in all grades, in terms of number of passes and quality of results;
- ✓ Increase the number of students qualified and competent to enter tertiary education institutions after obtaining their Senior Certificates and FETs; and
- ✓ Improve numeracy and literacy in lower grades in order to build a stronger foundation for future matriculants" (Draper: 2010: 17).

The Khanya project primarily had two developmental stages. Early stages of the Khanya project involved "establishing a dedicated space, room, or lab where the technologies were installed together with the educational software, internet connectivity and security, while the second phase focused on the educational use of the technologies, and included training of educators in the use of ICTs" (Isaacs, 2007). The Khanya project has achieved a lot in promoting the adoption and use of

ICTs in schools as evidenced by numerous awards received for its successful achievements (Isaacs, 2007). Draper (2010: 17) also claims that because of the initiatives of the Khanya project almost one thousand schools within the Western Cape Province have access to ICTs and teachers who were trained to use it.

2.4 Theoretical framework

This study is focused on understanding teachers' integration of ET for pedagogy in less affluent schools. Mathematics teachers are used in this study as an example. There is a growing body of research which shows that ET can enhance learners' conceptual and procedural knowledge of mathematics (Özgün-Koca, Meagher & Edwards, 2010; Kaput et al., 2007). Ozgun-Koca et al. (2010) stated that when teachers decide on how to integrate ET in curriculum delivery their decision must be underpinned by the following considerations. The teacher must consider the specific mathematics content they will be teaching, the pedagogical method they plan on utilising, and the specific ET they intend on employing (Ozgun-Koca et al., 2010).

The above-mentioned considerations force the teacher to reflect on the intricate connections between pedagogy, content and technology (Niess, Ronau, Shafer, Driskell, Harper, Johnston, Brownin, Özgün-Koca, & Kersaint, 2009). Niess et al. (2009) further stated that a teacher's ability to reflect on the intricate connections between pedagogy, content and technology is strongly related to how he/she was trained to integrate ET into curriculum delivery during teacher training. Furthermore, in order to cultivate knowledge of the different ET used in teaching and learning mathematics there is need for mathematics teachers to participate in training.

The concept of integrating different types of teacher knowledge is not new in teacher education. The importance of the relationship between different constituents of knowledge to increase curriculum delivery dates back to the works of Shulman (1986). Shulman (1986) emphasised the importance of treating pedagogy and content knowledge as basic requirement for teacher training. TPACK, formerly TPCK, was built on the works of Lee Shulman's concept of pedagogical content knowledge (PCK) to include technological knowledge (Koehler and Mishra, 2009). Their view is that there is not a specific way that ET must be integrated into a curriculum. For them, attempts to integrate ET must be creative and tailor-made to

create an environment structured in such a way that it meets the needs for a particular subject (Koehler & Mishra, 2009).

Education has changed over the past century. Before the 21st century good education referred to the ability to integrate content knowledge and pedagogy (Koehler et al., 2013). However, with the current technological advancements of the 21st century education has had to change to incorporate the technological advancements, hence TPACK was developed to help teachers to identify the type of knowledge that is suitable for ET integration.

Koehler et al. (2013) argues that many teachers lack the skill and knowledge (TPACK) on how to integrate ET for curriculum delivery. Chigona and Chigona (2010) agree with Koehler et al. (2013) positing that newly-qualified and experienced teachers in South African schools are not integrating ET in schools. In order to encourage integration of ET among teachers, they have to be taught how to use ET to enhance students' learning (Jimoyiannis, 2010). UNESCO (2008a) states that teachers should not be taught how to teach technology to students, but how technology can help them to improve curriculum delivery. Leendertz (2013) highlighted that in order for ET to be advantegous to teaching, it cannot be viewed as context-free. It must be connected to pedagogy. Figure 1 below shows the TPACK framework and its components that illustrate the interlinking of content, pedagogy and ET.

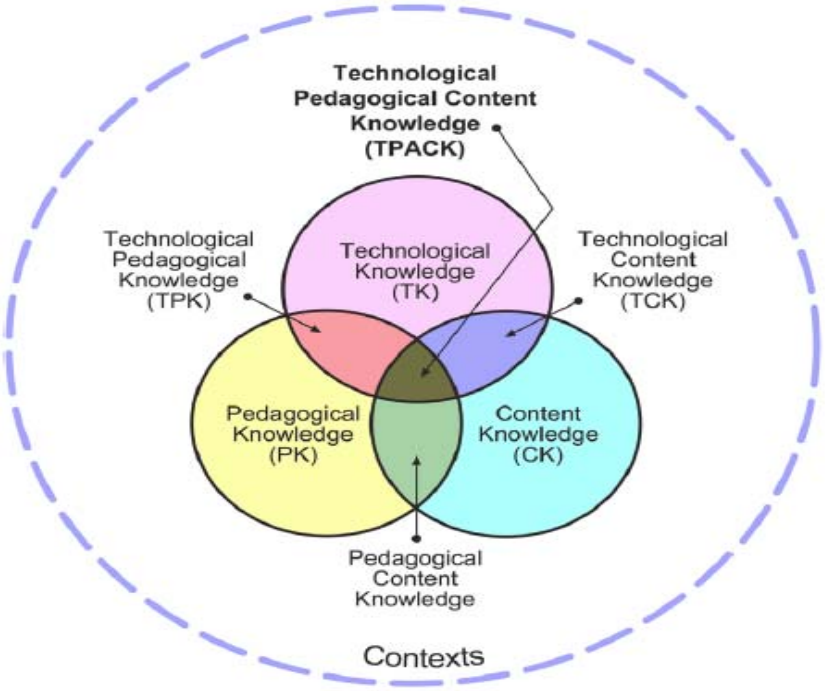

Figure 2.1: The TPACK framework

Source: Koehler & Mishra (2009)

Content knowledge (CK) refers to the subject knowledge of the particular subject being taught. Mathematics teachers, for instance, should hold appropriate content knowledge of the subject to teach it confidently (Mishra & Koehler, 2006).

Teachers learn this skill during teacher training. It is important for teachers to have a good understanding of the content they want to teach. This enables learners to be taught the correct information. When a teacher has weak content knowledge, the integration of ET will not enhance learning due to the teacher's limited knowledge. When teachers integrate ET and have good content knowledge teaching and learning is enhanced. This study is interested in determining whether a teacher's possession of strong or weak content knowledge influences his/her integration of ET. The researcher seeks to determine the importance of content knowledge to the integration of ET in mathematics classrooms.

Pedagogical knowledge (PK) refers to the ability a teacher should have to choose appropriate teaching methods when teaching particular concepts.

This is yet another skill that a teacher should possess beforehand. This skill should have been learnt during teacher training. A teacher should know how to teach a subject matter. However, when a teacher with good content knowledge has poor pedagogical knowledge, they will fail won't know how to best to deliver that knowledge effectively. As a result, using ET in such a case will not enhance curriculum delivery due to the teacher's failure to use the ET to facilitate teaching and delivering information. Thus, a teacher should have good pedagogical knowledge so that the combination of good pedagogy and ET curriculum enhances delivery. This study aims to find out if a teacher's PK influences integration of ET in the classroom. Does a teacher's possession of strong or weak PK influence his/her decision to integrate ET?

Pedagogical content knowledge (PCK) is a skill that is needed to link content/subject knowledge with good pedagogical practices. Pedagogical content knowledge is when a teacher can build a lesson basing on learners' prior knowledge, and having the ability to adjust their teaching methodologies to best introduce new content to learners (Mishra & Koehler, 2006).

PCK is another skill that teachers should possess when they come out of teacher training. This skill is important as it makes one a good teacher. A teacher who is weak in PCK will not know how best to deliver the information. Consequently, the environment created will not be good for curriculum delivery. In this study the researcher intends to find out whether a teacher's possession of PCK influences teachers' decisions to Integrate ET.

Technological knowledge (TK) refers to the ability and skills required to use various ET to teach specific content to learners. These ET include computers, the internet, calculators, didactic specific software and digital resources. Stoilescu (2011) stated that technological knowledge is a broad understanding of ET. TK necessitates teachers to understand ET broadly enough to apply it during curriculum delivery. TK allows teachers to distinguish when ET can help or impede attainment of a goal. TK incorporates a deep knowledge of various ET such as computers, the internet etc.

Strong TK signifies a teacher has the aptitude on how technological tools are used, and when to use them for optimum benefit for the learners. If a teacher has strong TK it means he/she will use ET in the classroom and knows how and when to use it. On the other hand, the researcher wants to determine if weak TK signifies an unwillingness to integrate ET on behalf of the teachers. If weak TK means teachers do not know when to integrate ET it becomes paramount for us to understand TK and how it influences mathematics teachers' integration of ET in their classrooms.

Technological content knowledge (TCK) refers to understanding ET in a specific subject (Stoilescu, 2011). It also refers to understanding how content can be imparted with the use of ET. TCK entails understanding how specific subject material can be changed by application of different ET.

The researcher wants to determine if teachers have subject knowledge of mathematics. In addition to this the researcher wants to determine if the teachers are able to combine the subject knowledge with knowledge of teaching the subject with ET. Furthermore, it is important to determine if teachers know how to present the subject content with different types of technological devices. It is incredibly vital then to note if knowledge of this fact encourages or impedes users' integration of ET in their classrooms.

Technological pedagogical knowledge (TPK) deals with the understanding that teaching can be shaped by ET (Stoilescu, 2011). TPK is an understanding of how curriculum delivery changes with the inclusion of specific ET. This takes into account the teachers having knowledge of the constraints that are offered by potential ET as well as knowing the benefits that they provide. This allows teachers to develop appropriate pedagogical practises which align with available ET.

TPK will guide this study by determining the influence of TPK on integration of ET into mathematics classrooms. The study aims to determine whether a teacher's possession of TPK influences their decision to use ET for curriculum delivery. It is imperative that a teacher knows that ET will change how classes are normally taught. The question is whether this knowledge affects integration in any way. If a teacher is

not well versed on how ET can shape pedagogy does this cause them to opt not to use ET? If this is the case, this study will give potential solutions to this problem.

Schmidt, Baran, Thompson, Mishra, Koehler, and Shin (2009:125) aver that TPACK "refers to the knowledge required by the teacher for integrating ET into their teaching in any content area. Teachers have an intuitive understanding of the complex interplay between the three basic components of knowledge (CK, PK, TK) by teaching content using appropriate pedagogical methods and ET." Mishra and Koehler (2006) argue that TPACK consists of knowledge of content, pedagogy, and technology. They further state that it involves an understanding of the complex interaction between these components. In addition, they say that teachers who are in possession of this type of understanding are creative and adaptive in ways which they navigate interactions within TPACK framework. Koehler and Mishra (2009) state that the solution of integrating ET into teaching lies in the capability of a teacher to navigate the three elements of content, pedagogy, and ET, and the complex connections among these elements in specific contexts. Table 1 below explains each of the 7 constructs of the TPACK framework.

Table 2.1: Seven constructs of the TPACK framework

Knowledge constructs Definitions	**Knowledge constructs Definitions**
Content knowledge (CK)	knowledge about the subject matter
Technological knowledge (TK)	knowledge about ET
Pedagogical knowledge (PK)	knowledge about the process or methods of instruction
Technological content knowledge (TCK)	knowledge to represent the content or the subject matter with ET
Technological pedagogical knowledge (TPK)	knowledge of the existence, components, and capabilities of various ET to be used in teaching
Pedagogical content knowledge (PCK)	knowledge of pedagogical strategies to teach specific content (subject matter)
Technological pedagogical content knowledge (TPACK)	knowledge of using ET to teach and represent the subject matter

Source: Chai, Koh & Tsai (2011).

A teacher possessing TPACK is regarded as one who has understood all the intricate interconnections of (CK, PK, and TK). This teacher should not have a problem determining when to use ET, and which pedagogical method suits a specific subject matter coupled with the appropriate ET. This is because TPACK provides the basis of true technological integration and it is expected that possession of this skill means a teacher has enough arsenal to make decisions regarding how and when to properly integrate ET in the classroom. In relation to this study, it is important to interrogate if possession of this skill automatically means that teachers will integrate ET into their classrooms, or if a lack of this knowledge automatically means teachers will not integrate these ET. Also, it is important to see whether teachers have TPACK

or not, to determine if measures must be in place to improve TPACK amongst mathematics teachers.

After careful consideration Technological Pedagogical Content Knowledge (TPACK) was deemed as the suitable framework to underpin this study. It was chosen because it involves an understanding of the intricate connections between the use of ET in the classroom and pedagogical content knowledge (Mishra & Koehler, 2006). TPACK is a framework that aims to guide teachers on how best to go about integrating ET in their classrooms. As such, TPACK provides the best guidelines of what skills teachers must have to be able to integrate ET into their classrooms. Thus, it is of interest to note whether possession of this skill has any influence on the ability and willingness of teachers to integrate ET in mathematics classrooms.

The TPACK framework has its weaknesses, though. According to Graham (2011), TPACK lacks theoretical development. It was founded on Shulman's (1987) Pedagogical Content Knowledge (PCK) framework, a framework that in itself lacks theoretical clarity. The framework inherently possesses a high degree of parsimony. The TPACK framework is over-simplified, and does not take into consideration factors beyond content, pedagogy, and technology, such as teacher beliefs and context. The framework also comprises of different classifications that do not have precise definitions. Nkula & Rauss (2014) aver that there are 13 distinct definitions for TCK, 10 definitions for TPK, and 89 for TPACK. Despite all these shortcomings, PACK is still a powerful framework that provides insight on the skills that teachers need for integration.

2.7. Summary of chapter

In this chapter we have dealt with several issues relating to the integration of technology for pedagogy in less affluent schools in the Western Cape. These issues provide direction to the research designs and research methodology. The literature listed the different issues that are affecting the integration of ET in our schools, and it showed the immense advantages that ET posit if effectively utilised for curriculum delivery. The researcher shall explore the challenges teachers experience in integrating ET for pedagogy and understand their reasons for integrating or not

integrating ET in their classrooms. This will be done with the aim of providing recommendations to the WCED, the principals and teachers who have access to some level of ET in high schools in less affluent areas.

RESEARCH DESIGN AND METHODOLOGY

3. Introduction

This qualitative study follows an interpretive paradigm and phenomological design in order to understand teachers' integration of ET for pedagogical use in less affluent high schools. The TPACK model underpins this study as its framework. Qualitative research is used to attain a comprehensive understanding of participants' behaviour, experiences and motivations (Schurink, Fouche & DeVos, 2011). Denzin and Lincoln (2011) stated that a qualitative research approach aims to attain the participants' understanding of their world in their ordinary environment. The reason the researcher chose qualitative research was because of the advantages that it holds. The approach allows the investigator to get complete data and contributes detailed explanations of the problems under study (Denzin & Lincoln, 2011). In addition, it encourages participants' individual opinions to be reflected which adds to the richness of data (Denzin & Lincoln, 2011). However, its shortcomings include the time it takes in-order to get valid and reliable results (Huberman, Mathew and Miles ,1994). This emanates from the fact that several research methods can be used in one study. Consequently, it takes longer during analysing and coding of data (Huberman et al., 1994).

This study is concerned with understanding each individual participant's knowledge of the different ET and their opinions on its integration in the classrooms. Participants' views and opinions are construed through their experiences with ET integration. The phenomological design was opted for in this study. Phenomological design involves investigating how the situation was experienced, and the meaning subsequently attached (McMillan & Schumacher, 2006). The design is appropriate as its prominence is on the participant's subjectivity as they integrate ET. Thus, the experiences of mathematics teachers with ET integration are pivotal to this study. An interpretative paradigm will be used as it gives the context of the phenomenon being studied (Reeves & Hedberg, 2003).

Cohen, Manion and Morrison (2011:116) posit the following: "An interpretive paradigm rests, in part, on a subjective, interactionist, socially constructed ontology and on an epistemology that recognized multiple realities, agentic behaviours and

the importance of understanding a situation through the eyes of the participants". The interpretative paradigm gives each participant's view of the reality being studied., It is used with an understanding that everyone sees the world from a different perspective, meaning it is improbable to find universal truths (Walliman, 2011). Greene (1994:536) posits that an interpretive study is "unabashedly and unapologetically subjectivist". Interpretation allows for the elaboration of existing ideas and additionally the formation of new ideas surrounding a particular idea (Altheide & Johnson, 2011). This in particular is relevant to this thesis, especially considering the problematisation of an existing, theoretical framework, i.e. "TPACK" (Mishra & Koehler, 2006). To address the problems of subjective qualitative research methods such as using transparent processes like member checking of transcripts and triangulation are used.

The following issues will be discussed in this chapter:
Section 3.1: Research design

Section 3.2: Data Collection

Section 3.3: Data Analysis

Section 3.4: Trustworthiness

Section 3.5: The researchers' position

Section 3.6: Ethical consideration

Section 3.7: Conclusion

3.1 Research design

A research design is a method used to address research concerns or enquiries. It is important that researchers formulate a plan that summarises procedures for collecting, analysing, and reporting data. These procedures will be guided by the research questions. It is of paramount importance for researchers to have in-depth knowledge of the methodological and analytical tools available, including their advantages and disadvantages (Dzansi & Amedzo, 2014). The qualitative research

approach was used for the study. Schurink et al. (2011) postulates that qualitative research is used to gain in-depth information on participants' attitude, behaviour, aspiration, culture of lifestyles and aims to understand the social and human problem. The qualitative approach was preferred as it allows the researcher to be closer to the participants. It enabled the researcher to learn from the experiences of the participants. As such, the interpretive paradigm was followed to deal with data generated from both semi-structured face-to-face interviews and observations.

3.1.1. Population and Sampling

Kombo and Tromp (2006) aver population as a group of items, objects or people from which samples are considered for measurement. Strydom and Delport (2011:223-224) coined that population refers to people that have certain features that the researcher is interested in. The population of the study was teachers in less affluent high schools. There was specific attention given to mathematics teachers in these high schools. This research was conducted in 2 public high schools randomly selected from the Metro South districts of the Western Cape Province. The choice of two public high schools was sufficient to address the research questions and problem. This district was chosen because of its close proximity to the researcher's residence making it cost effective while still providing valuable data. The two high schools were selected using a simple random sampling technique in order to reduce the chances of the researcher bias. To accomplish this sampling the researcher obtained a list of public schools within the Metro south district of the Western Cape. Names were written on a piece of paper and the researcher picked two names from the container at random. Any of the identified schools had the same probability of being chosen throughout the sampling process (Thompson, 2012). The names of the two schools were withheld and substituted with alphabetic pointers to promote confidentiality. The researcher chose these two schools because they had received ET via the Khanya project. This means these schools had technological resources making them suitable sites to conduct this study.

3.1.2 Sampling

Sampling is a procedure whereby participants from whom information is gathered is undertaken. Sampling helps the researcher to decide how best to get the best

solutions to the problem (Dzansi & Amedzo, 2014). Walliman (2011:185) asserts that a sample is a carefully chosen number of cases in a population. He further continues to say that sampling must be undertaken whenever a researcher can gather information only from a fraction of a populous (Walliman, 2011). Random sampling was used to choose the school were the data was collected. The names of all public schools where put into a hat, and the researcher just picked up names of the two schools he would carry out the research at without looking. The schools were randomly chosen, and every school had a chance of being chosen. The schools were randomly chosen by chance. This study had a total of 9 participants. These 9 participants were purposively chosen as the researcher chose mathematics teachers as participants. The reason of choosing mathematics teachers was because improving mathematics learner's performance is one of the core mandates of the executive summary of the National Development Plan (NDP) (Stols, et al., 2015). These mathematics teachers were purposively selected because during the implementation of the Khanya Project mathematics was one of the preferred subjects targeted for use of installed ET. "Purposive sampling targets individuals who are 'typical' of the population being studied" (Davies, 2007:57). Maree (2007) argues that purposive sampling is when participants in a research are chosen because of some defining characteristic. Walliman (2011:188) stated that purposive sampling is "where a researcher selects what he thinks is a 'typical' sample."

The sample size of the study was determined by factors such as the budget, time and resources needed to carry out a meaningful research. Time was of essence because the researcher had to source the sample, get their consent and collect data, which is a strenuous procedure. Budgetary constraints also influenced the decision on the sample size. The researcher had limited resources at his disposal. While a large sample could result in vast amount of valuable data being collected, it may require a team of researchers to collect such data entailing more expenses the researcher could not afford. The chosen sample size was reasonable and manageable in line with the available budget, time, and resources.

3.1.2.1 Biographical information of participants

The demographic information of the educators that participated in the study is listed in Table 3.1 below. Table 3.1 includes information such as the gender of the participants, years of teaching experience and racial group.

Table 3.1: Demographic features of the participants

Pseudonym	Years of experience	Gender	Racial group
Teacher A	2 yrs	female	Colored
Teacher B	40 yrs	Male	Colored
Teacher C	8 months	Male	Colored
Teacher D	6 months	Male	Black
Teacher E	15 yrs	Female	Colored
Teacher F	29 yrs	Male	Colored
Teacher G	16 yrs	Male	Black
Teacher H	6 yrs	Male	Colored
Teacher I	21 yrs	Female	Colored

Table 3.1, above, shows that the educators who participated in this study had a wide range of experience among them. The teaching experience ranged from as little as 6 months to 29 years of teaching mathematics. The sample included both veterans and novice teachers. Such a wide spectrum allows for a more realistic representation of teachers from different eras.

Most of the mathematics teachers in the two schools were predominantly male. Male teachers accounted for over 60% of the maths teachers in this study. Table 3.1 above also shows that over 75% of the educators were colored. This is likely a product of the location of the schools. Statistics South Africa (2011) posits that 48.8% of the Western Cape population is coloured, 32.7% black, 15.7% white and 1% Asian. This distribution goes some way in explaining the racial distribution amongst the teachers at the schools.

3.2. Data collection

Creswell (2014) posits that in a qualitative research there are various data collection instruments that can be used. For this study semi structured interviews *(see appendix A)* were used as data collection instruments. Semi-structured interviews were used to collect data from the mathematics teachers who formed part of the sample. This particular data collection tool allows the researcher to get first-hand information as to what influences teachers to integrate ET in mathematics classrooms. The researcher also used observations for data collection. Observations were key to determine if what the teachers had said during interviews was exactly what they did in the classroom. It allowed the researcher to consolidate the information received during interviews to make the data collected valuable and significant.

3.2.1. Semi-structured Interviews

According to Walliman (2011) interviews can be carried out in different situations like home, work or the outdoors. He further goes on to say that interviews can be conducted face to face or telephonically. Interviews can be once-off, longitudinal studies or repeated over a period of time to track development (Walliman, 2011). Maree (2007) argues that an interview is a two-way conversation between the interviewer asking the participant questions. He further argues that interviews are done in order to collect data about the participant's ideas, views or opinions. Creswell (2009) purports the following characteristics of interviews, namely — individual in-depth, exploratory, semi-structured or unstructured.

The researcher opted for a semi-structured interview, primarily because it allowed the researcher to probe deeper and leave time for further development of answers given. At the same time, participants provided defined answers to defined questions (Walliman, 2011). The researcher ensured that interviews were not side-tracked by trivial aspects that are not related to the study (Maree, 2007). Furthermore, it was important to know what was to be done with the gathered information (Walliman, 2011). Selecting semi-structured interviews allowed the researcher to modify questions at the researcher's discretion depending on the response from the participants. During interviews the researcher aimed to collect information regarding teachers' experiences with ET, factors they feel contribute to integration of ET and their general views on the role of ET in mathematics classrooms.

The teachers were interviewed to get their opinions on factors that influence their integration of technology. Interviews were guided by the seven constructs of the TPACK framework (Mishra & Koehler, 2006). Each question that the researcher asked was guided by the TPACK framework. Each question asked in such a way that the researcher would establish whether the teacher was in possession of technological knowledge or pedagogical knowledge.

During interviews the researcher listened and wrote down what the participants said. The participants expressed themselves fully with the researcher only speaking when seeking clarity or when probing for more information. With permission from the participants, interviews were recorded alongside field notes. The researcher obtained permission from the principal, teachers, WCED and the universities ethics committee to conduct these interviews and observations. Each teacher was interviewed to get their opinion of factors affecting the integration of technology in classrooms in their schools.

The interviews lasted around 50 minutes each. They were recorded digitally and transcribed later. The interviews sought to obtain teachers' feelings on the integration of technology and its place in teaching and learning of mathematics as a subject. The teachers were asked about their reasons for using ET, and if they did not use it, reasons for doing so. The teachers were also asked to clarify If they felt ET had any advantages. This was used to see each teacher's perception of the usefulness of ET

in teaching and learning, particularly of mathematics.

3.2.2. Observations

“An observation is the systematic process of recording the behavioural patterns of participants, objects and occurrence without necessarily questioning or communicating with them” (Maree, 2007:83-84). The researcher was a non-participant observer. This means the researcher merely observed lessons, and did not interact with the class in any way (Davies, 2007). Advantages of being a non-participant observer are that it is the least obtrusive form of observation (Maree, 2007). The objective of this exercise was to see how teachers teach with the aid of technology and to ascertain whether the inclusion of technology helps improve pedagogy or student engagement. The researcher chose to be a non-participative observer to avoid influencing the events in the classroom. He wanted the lesson to take place without any disturbance. By being a non-participative observer, the data collected was not subject to bias as events would be taking place as they would on any day. Persistent observations are utilised in order to identify traits relevant to the study and answer the questions posed in this study, and to identify those not relevant so they can be eliminated for analysis purposes. This gives the researcher ample time to observe more traits relevant to the study (Lincoln and Guba, 1985)

3.2.2.1 Reasons for choosing observations

Observations allowed the researcher to gain first-hand experience on how teachers are integrating technology. The researcher observed how teachers integrated various technologies into their classrooms. Observations were only undertaken in cases were the teacher taught with technology, or when the teacher decided that the topic, they were currently teaching needed technology to be integrated (TPK). Thus, interviews were the primary technique for data collection. Observations were utilised whenever a suitable opportunity presented itself. Persistent observations were used in order to identify traits relevant to the study, and answer the questions posed in this study as well as identifying those not relevant so they can be eliminated for analysis purposes. This gave the researcher ample time to observe more traits relevant to the study (Lincoln and Guba, 1985). Their lessons were also observed in order to identify

if they possessed TPACK, and to ascertain how the teachers' TPACK affect their integration of technology and pedagogy.

Observations allowed the researcher to gain first-hand experience on how teachers are integrating technology. The researcher observed how teachers integrated various technologies into their classrooms.

Observations enabled the researcher to observe the extent to which non-academic factors affect a teacher's decision to use ET for pedagogy. Of more importance is the ability for the researcher to perceive information that could have been missed out during interviews. Observations are central to this study. They were used to ascertain the complex relationship of teachers and their decision to integrate ET for pedagogy. Observation, however, has a disadvantage as data collected is subject to bias. To minimize bias, the researcher developed an observation schedule together with a detailed description of what the researcher had to look for during observation in the classroom.

3.2.2.2 Observation procedure

I sat in the classroom observing the proceedings of the lesson and did not participate in classroom activities (Walliman, 2011:195). The teachers explained my presence to the learners in the classrooms, and this encouraged learners to act naturally during the period of my observation. During the observation period the researcher was writing down notes on an observation schedule (Appendix B). The researcher noted down any event that answered the research questions posed by this study. The researcher observed if teachers where using ET and if they had good TK, TPK, TCK as well as determining if any of the teachers were in possession of TPACK.

3.3. Data Analysis

De Vaus (2001:9) is of the opinion that "the function of a research design is to ensure that the evidence obtained enables us to answer the initial question as unambiguously as possible". In order to answer the initial questions asked the researcher used semi-structured interviews as a data collection instrument. In

Qualitative research the aim is to seek understanding and extrapolation of similar situations (Hoepfl, 1997:47-63). Henning (2004:36) endorses the analysis of qualitative data right from the onset of the data collection process, with the researcher continuously reflecting on connections and relations as the researcher continues collecting, dividing, categorizing and grouping data into more meaningful smaller units.

Interviews with the participants were recorded and transcribed. The researcher re-read the transcripts a few times over to ensure the transcription process was accurate and error free. Re-reading the transcriptions also helped the researcher formulate a deeper understanding of each individual participant's experience. Data analysis must be undertaken in relation to the research problem and aims of the study (Walliman, 2011). Walliman stated that the nature of the research problem will determine which analytical method must be incoporated. A qualitative analysis was used, specifically coding. Walliman (2011) describes coding as forming typologies and taxonomies from copious data (in the form of notes or transcripts) by identifying differences in the data thereby forming subgroups within the general category. Maree (2007) claims that coding is when transcribed data is read prudently line by line, and divided into significant logical units.

Maree (2007) is of the opinion that data analysis tries to make use of participants' feelings and experiences to try and establish how they make meaning of a certain phenomenon. After the data has been collected the researcher coded it. The qualitative data analysis was undertaken with an inductive approach being used. Induction is a scientific activity that leads people to make conclusions from their everyday experiences (Walliman, 2011).

Creswell (2014) argues that the inductive approach starts with the researcher gathering information from the participants and then forms the acquired information into themes, which are later developed into broad patterns which are then compared to existing literature on the topic or personal experiences. The researcher subsequently opted for the inductive approach in order to generate themes based on the data collected. Any additional codes that came up during the analysis process

were also incorporated so as to truly reflect the experiences of the respondents (Creswell 2007).

Figure 3.1. below shows the inductive reasoning in qualitative studies

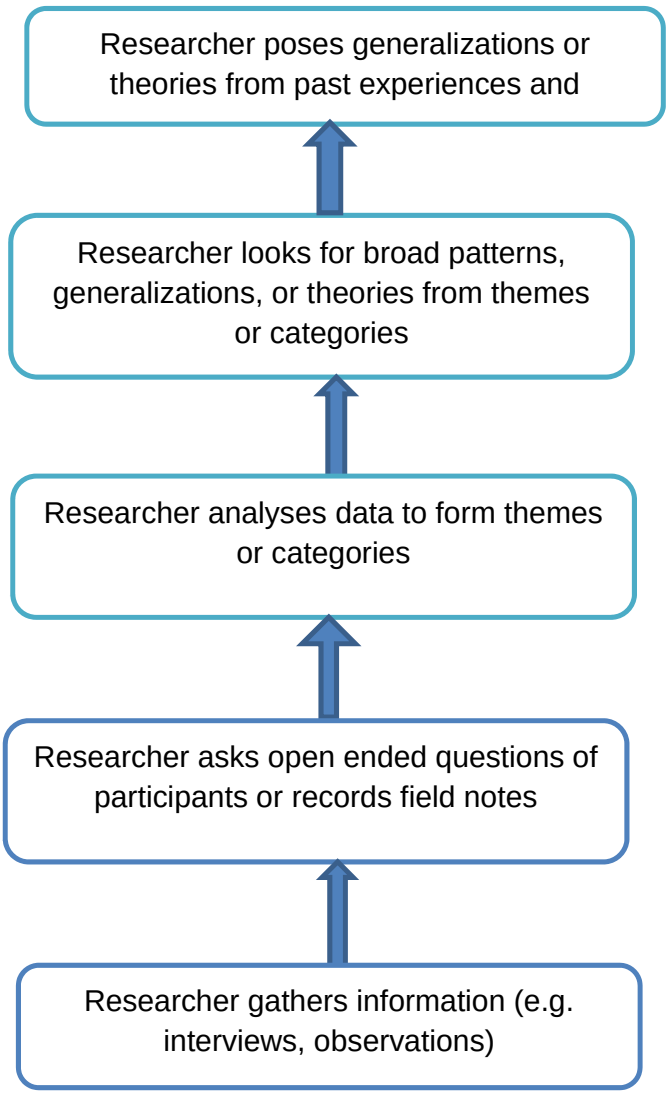

Figure 3.1: Inductive reasoning in qualitative studies

Source: (Creswell, 2014)

The qualitative data analysis was undertaken while embracing TPACK and the use of the inductive approach. The study focused on the seven aspects of the TPACK framework — namely Content Knowledge (CK), technological knowledge (TK), Pedagogical Knowledge (PK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), Pedagogical and Content Knowledge (PCK) and Technological Pedagogical and Content Knowledge (TPACK).The researcher focused on each of the aspects of the TPACK framework and checked if the participants possessed all the 7 aspects that make up the TPACK framework. The aim of this exercise was to determine if the participating teachers did not have an aspect like Technological Knowledge (TK) and if this would have a bearing on their willingness or ability to integrate ET into their mathematics classrooms. So, the researcher looked at every aspect of the framework and tried to conclude on each aspect's influence on teacher's willingness to integrate ET into a mathematics classroom.

3.4 Trustworthiness

Marshall and Rossman (2010:39) points out that trustworthiness ensures the reliability of results obtained by a study. Credibility, transferability, dependability, confirmability and reflexivity, among others, were used in this study to prove the trustworthiness of the research findings. These components, which are discussed in more detail below, were applied to both the interviews and observations which formed the data collection instruments for this study.

Lincoln and Guba (1985) mention that in order to guarantee trustworthiness in qualitative research there are aspects that must be followed. These aspects are prolonged engagement, persistent observations, structural corroboration, referential adequacy, member check, and triangulation. Prolonged engagement is when a researcher is in the classes for an extended amount of time in order overcome situations where teachers change their teaching style particularly because the researcher is sitting in the class. Lincoln and Guba (1985) continue to postulate that by attending many lessons respondents become used to the presence of the researcher and that way the data collected is free of any distortions. Creswell (2014) is of the opinion that prolonged engagement gives a deeper understanding of the

issues being studied. Furthermore, the more experience the researcher has with participants in their setting, the more valid the findings will be. Persistent observations are used in order to identify traits relevant to the study. Referential adequacy is when the researcher tests his interpretations against various sources of data (Lincoln and Guba, 1985).

In an attempt to establish trustworthiness, the researcher used member checking. Member checking is when the researcher took the themes or the final report back to the participants in order to determine whether the participants feel that the findings are accurate (Creswell, 2014). Member checking was used so that participants may see that the transcribed words are their own and that the researcher did not add or remove any information. Data triangulation was also undertaken. This is whereby the researcher used information from different data sources, e.g. observations and interviews, to build themes and a coherent justification for themes thereby adding validity to the study (Creswell, 2014).

According to Creswell (2014) clarifying researcher bias is another way of establishing trustworthiness. He posits that self refection creates an honest narrative that resonates well with the readers. Additionally, it clarifies how the researcher could be affected in terms of interpretation based on their background and other factors like gender and culture.

Trustworthiness is of paramount importance to qualitative research. Three facets of trustworthiness were taken as areas of focus for the study — namely credibility, dependability and conformability. Credibility ascertain that the results obtained by the research are authentic. This was achieved through going over the data to make sure that no themes were omitted. Credibility ascertains that the participant's personal views on the area of study are acknowledged, and that the researcher will make sure that data collected indicates this. Dependability is when the researcher makes sure that the research process is sound and audited (Schurink et al., 2011:420). Dependability means that if the study was to be repeated under the same context with the same participants, results obtained would be the same.

Conformability necessitates that result obtained from the study will be results of the experiences and ideas of participants as opposed to the partialities and bias of the researcher (Shenton, 2004:72). The researcher clearly explained the questions to the participants to try to be objective and give responses not leaning on their biases. By interviewing the participants repeatedly, the researcher increased his chances of being able to distinguish a response that is biased. The researcher probed further to make sure answers received were bias-free.

When the researcher started doing interviews at the schools there was an element of bias that could creep in. The researcher did not let his personal feelings influence the data collection process. He was impartial and did not influence the participants in any way. Table 3 below shows the steps taken to ensure trustworthiness.

Table 3.2: Steps taken to ensure trustworthiness

Credibility	The use of more than one source of data and more than one data collection method; use of member checking and allowing participants to review synthesis of interview data.
Applicability	Interpreting data in accordance with research questions; use of member checking and allowing participants to review synthesis of interview data.
Consistency	Ensuring consistent compliance in terms of data collection methods; detailed descriptions of participants' sample, data collection methods and strategies for analysis.
Neutrality	Ensuring non-interference. Recording as truthfully as possible, raising additional questions where necessary.

Source: Krefting (1991:215)

3.5 The researcher's position

Due to the fact that the researcher works at the school were data was collected, there was a disposition to lean towards certain themes and actively seek evidence to support these themes. The researcher became vigilant not to lead participants in certain ways. Participants spoke freely and all information was recorded verbatim. The researcher was merely a facilitator and did not try to lead participants in any

specific direction. Another possibility that arose was to try to paint the school in a positive way as the researcher works there and was interviewing his superiors. In this regard the researcher interpreted the data collected as it was presented and did not allow the association with the school influence how the data was interpreted. Furthermore, the keeping of the names of the schools anonymous made the participants feel safe to say their mind allowing for genuine data to be collected.

The researcher also had opinions about the schools because of his association with them. However, the researcher did not let these opinions influence him or cause participants to answer questions in a particular manner. The participants were allowed to answer the questions as they saw fit with no interference whatsoever from the researcher. In order to keep the data collected as accurate as possible the researcher held himself responsible to make sure that data collected reflected the participants view as accurately as humanly possible. The researcher's perception on ET integration was shaped by the researcher's own experiences with ET integration when he was still a high school student. The researcher admits this may have a certain bearing on the way the researcher views and understands the collected data. To this cause every effort was made to ensure objectivity.

3.6. Ethical considerations

Ethics deal with ideals of what is right or wrong (McMillan & Schumacher, 2006). Ethics are a set of principles for good professional practice, which advise the researcher how to conduct their study (Bloor and Wood, 2006:64). The researcher obtained ethical clearance from the Cape Peninsula University of Technology and the Western Cape Educational Department (WCED) *(see appendix C and D respectively)*. The researcher obtained authorization from the school principal and teachers from where the data was collected *(see appendix E)*. Anonymity was guaranteed and all participants were made fully aware of what the research entails. At any stage participants could withdraw as participation was entirely voluntary.

Kumar (2005:212) concludes that it is unethical to collect data without getting permission of the participants and without getting their consent first. In respect of the above the researcher explained the purpose of the study to all involved participants

so they could willingly decide whether or not participate in the study. The names of the schools are not included in any of the data collection forms as suggested by Bloor and Wood (2006:68). The names of the teachers were also not included in the study. Pseudonyms where assigned to describe the teachers as teacher A, teacher B and so forth. No research participant was coerced into participating in the research. The researcher was the interviewer. The researcher visited the school with permission from the WCED and ethical clearance from the university. The researcher on his part as interviewer did not suggest or lead the interviewees in a certain direction through leading questions. He was guided by the semi structured questionnaires.

3.7. Conclusion

This chapter has described the research methods and methodology of the study on integration of ET Integration for pedagogical use in mathematics classrooms in the Western Cape. The researcher has clarified the processes that were followed in collecting and analysing the data. The data instruments used have been discussed and the reason why they were opted for. The researcher has also detailed why he opted for a qualitative approach together with issues relating to conducting research within my own work place. This chapter has also dealt with a spectrum of relevant concepts, including triangulation and validity. In addition, this chapter also explored the ethical issues and steps the researcher took to conform to the ethical considerations of valid research. In the next chapter the researcher presents the data from the various data sources and begins the process of analysing and interpreting the data.

FINDINGS AND DISCUSSIONS

4. Introduction

This chapter presents and discuss the findings of the study. The main purpose of this chapter is to describe how participant responses aided the researcher in answering the research questions. The chapter make sense of the data and presents the acquired information in a sensible and sequential manner.

Semi-structured interviews and non-participative observations were the tools used to collect data for this study. The researcher sought to identify teachers' perception and feelings about ET integration in mathematics classrooms in less affluent schools in the Western Cape. The interviews helped shed light on each individual teacher's feelings on ET and its role in mathematics curriculum delivery. Observations showed how many teachers used ET, and of those who use ET the researcher observed their levels of competency. Integration of ET in curriculum delivery is of interest because literature suggests that in order to meet 21st century learning skills, the curriculum should incorporate ET.

Nine educators complied to participate in this study. These participants will use pseudonyms teacher A to I for purposes of identification and to guarantee anonymity. Presented herein are the findings of various data sources under separate themes. Verbatim quotations were written in 'italics.

The key questions that are guiding this study are:

What are the factors that affect the Integration of ET by mathematics teachers for pedagogy in less affluent High Schools in the Western Cape?

Sub-questions

1. What challenges do mathematics teachers have with the Integration of ET for teaching and learning?
2. What do mathematics teachers perceive as the benefits of using ET for curriculum delivery?

Thematic data analysis was done as described in chapter 3. Coding was done during the analysis. As a result, themes and sub-themes were formulated and are listed below.

1. Teacher familiarity with the integration of ET
2. Teacher challenges with the integration of ET
3. Advantages of integrating ET for curriculum delivery

The above three main themes were recognized from the data and some themes incorporated several sub-themes. The first theme concentrated on teacher familiarity with using ET. The focus was on teachers' experiences with using ET and their experiences with integrating ET or the lack thereof. The second focused on challenges with integration of ET, that is, what challenges teachers had with integrating ET and if these played a role in their decision to integrate ET or not. The third dealt with teacher perceptions on the advantages or disadvantages of integrating ET for pedagogy. It was important to understand if these perceived advantages or disadvantages play a role in influencing teachers' decisions to integrate or not, ET for pedagogy. The last theme dealt with how teachers integrated ET. This focused on the processes they went through as they decided which ET to use and how to use it for curriculum delivery.

The rest of the chapter is structured into the following sub-sections:

4.1 Teacher familiarity with the integration of ET

4.2. Teacher challenges with the integration of ET

4.3. Advantages of integration of ET for curriculum delivery

4.4 Summary of chapter

4.1 Teacher familiarity with the integration of ET

This theme focuses on teacher's familiarity with the use of ET for pedagogy. The main focus was to ascertain if teachers had prior experience with using ET, either back in teacher training, previous schools or at their current school where the

interview took place. The reason this theme was important was because Nkula and Krauss (2014) posit that despite the opportunities offered by ET, many schools in developing countries such as South Africa do not have access to ET. Teachers who work in such schools probably have never been exposed to ET in their whole careers. As such, it was important to determine if teachers had familiarity with ET and if this was an influencing factor in their decisions to integrate or not, ET for pedagogy.

The researcher posed the question whether teachers had received any training regarding the use of ET for pedagogy. The following are responses from the teachers:

> *I was, we were formally trained by the WCED. But I think I was born with that technology in my background and I just know how to use it* ***(Teacher A).***

> *From varsity, they explain it. There is actually courses where they explain how to use the smart board and that. So ja we got training from varsity already* ***(Teacher C).***

> *Not at all. I had to learn on the job. And also, I attended a few refresher courses, or I can say, seminars on the use of technology. But most of the experience I gained on the use of ICT, I had to learn on the job (****Teacher G).***

It is clear from the above narratives that regarding training on the use of ET for pedagogy teachers had vastly varying experiences. Some teachers got training at the university during teacher training while some got training on the job. Four of the 9 participants said they had been trained to use ET during teacher training. Coincidentally, these are teachers who had recently graduated from teacher training with less than three years of experience. The same phenomena were described by the U.S National Centre for Education Statistics (2000) which postulated that teachers who have been teaching for about 3 years were using computers 48% of the time compared to teachers with between 4- and 9-years' experience who reported to using computers 45% of the time. This means teachers who had just left teacher training institutions were found to have been trained to integrate ET for pedagogy unlike their senior counterparts.

The rest of the teachers said they had learnt about integrating ET during seminars hosted by the WCED, and they had to go out themselves and seek more information and help on integrating ET for pedagogy. Despite lacking training on how to utilise ET for pedagogy during their school days some teachers, particularly the older teachers, got exposed to ET because of seminars on ET use. Thus, all of the teachers involved were familiar with ET to some extent. They had considerable knowledge about ET and its benefits for pedagogy. What varied however was the level of familiarity as that was influenced by the level of engagement with the ET.

Having established teacher familiarity with ET it was now important to determine the level of familiarity. This would be determined by checking if teachers were utilising ET at all, in their classroom. It was also important to understand the reason why teachers would integrate or not, ET for curriculum delivery. Keen interest was on engaging those teachers who did not integrate ET to see if they had received any training and understand if familiarity with ET was a reason influencing their choices to integrate ET or not.

The researcher asked the interviewees if they utilised any ET for curriculum delivery. The responses were compared against what was observed to see if teachers really were using technology in their lessons. Out of the nine respondents, seven (77%) teachers indicated they used some sort of technology for mathematics curriculum delivery. The remaining 33% stated that they did not utilise ET for curriculum delivery for various reasons. The reasons include the following:

> *I do not have the technology devices in my class due to theft. However, I am very willing to use it as I can see the need to keep up with the new methods of teaching that involve technology (**Teacher E).***

> *My own laptop is at home. When I have my projector, I bring my laptop to school. At the moment there is no reason. There is a computer room, but it has a time table and the time table does not work for me (**Teacher I).***

The responses above, from teachers who work at different schools, show that they do not use ET because of its absence in their schools. Teacher E stated that her class had been targeted by thieves, and as such, the technological apparatus was stolen. Theft was the reason she was not integrating ET. This combined with the fact that schools in less affluent high areas are usually not financially strong meaning that it may take longer to get the devices replaced. Voogt and Tondeur (2015) found out a similar result, and postulate that poor infrastructure discourages teachers in less affluent areas to integrate ET. Teacher I stated that the ET was only available in the computer lab of which, in order to use it, she had to follow a particular time table which may not always coincide with her hectic schedule. She did not integrate ET because she lacked the necessary infrastructure to do so in her classroom. As Voogt and Tondeur (2015) pointed out, financial and connectivity problems were seen to discourage teachers from using ET. Teacher I also struggled with the time due to the clashing timetables of her lessons and the computer lab. Stols et al. (2015) clearly points out that to many teachers lack of time was a common caused many teachers to have an unfavourable view on Integrating ET into their classes.

These results illustrate that most mathematics teachers in the sampled public schools had familiarity with incorporating ET in their classroom teaching. The few teachers who do not utilise ET do not necessarily have any ill feeling towards ET. There are various reasons for them not utilising ET. These will be discussed in depth in the following sections.

The researcher observed lessons of all the participants involved in the study. The reason was to see if claims made by educators that they knew how to utilise ET in their teaching had any basis.

> *Do I have technical skill... yes, I do have? They have enabled us at school to do… to use the technology. I did not do computers at university or college, but we had classes here, endless classes here where the department sends people to educate us how to use the technology* ***(Teacher C).***

Despite teacher C stating he used technology in his lessons observations actually proved otherwise. Despite teacher C having gone through countless training sessions he still did not utilise ET for curriculum delivery. The reasons as discussed in this section included theft, lack of the technological devices and lack of time.

What is interesting to note is that most of the teachers used ET for curriculum delivery as they had stated in the interviews. What constituted as using ET in most of these cases was using a laptop attached to a projector, with PowerPoint slides being displayed on a white board. In some cases, they used the projector to play videos for the learners. Using ET to play videos for the learners has advantages for the learners, as stated by Stoilescu (2011 citing Kaput and Thompson, 1994). Facilities like videos and audios offer better teaching and learning opportunities compared to static media by providing opportunities for lively interactions. Therefore, by integrating videos into teaching educators are providing a better learning environment for their learners.

Word documents were used by some educators to put up mathematics questions. The teacher would work these out on the white board as learners took down notes. None of the educators in this study utilised the interactive white board (IWB) for curriculum delivery. The way ET was utilised in these less affluent schools by some of the educators concurs with what Nkula & Krauss (2014) found when they noted that ET in many poor schools in developing societies like South Africa is '*implemented without integration'*. Implementation *with* integration is a situation where students utilise ET to learn, with ET being an integral part of curriculum delivery (Nkula & Krauss, 2014). Some teachers used ET to merely display information, acting more like a substitution of the traditional chalkboard.

The responses above prove how teacher's familiarities with technology varied from one teacher to the next. Some educators did not use technology at all while some used it daily. Other educators were taught how to use ET for curriculum delivery during initial teacher training. There were also those who learnt on the job and those who did not bother to learn at all.

Teacher familiarity helped to answer the main research questions which sought to identify factors affecting the integration of ET in less affluent high schools. Familiarity was gained through initial training during teacher training. Secondly, workshops conducted at schools provided familiarity. Getting learners familiar with ET during teacher training proved an important factor to encourage integration of ET for pedagogy. Most young, inexperienced teachers reported utilising ET for teaching. Other reasons affecting the integration of ET for pedagogy included theft of ET

devices, lack of infrastructure and poor technological support at the schools. Schools in less affluent areas are usually poor and located in resource-constrained areas which are usually infested by criminals. The schools experienced break ins and some of the ET devices were stolen. Crime is a factor that affect teachers who may be interested in integrating ET for pedagogy. Thus, many schools in these areas need more security to avoid such break ins from happening.

Teacher familiarity brought forward the notion that factors that affect integrations are interlinked. It is not always the case that teachers do not integrate because they lacked training in integrating ET. Some received training but the schools do not have the infrastructure to allow the integration of ET for pedagogy. All these factors must be dealt with to create an environment that encourages the adoption of ET for teaching and learning.

4.2. Teacher challenges with the integration of ET

Teacher challenges refer to problems or situations teachers may face that are affect their attempts to integrate ET for curriculum delivery. This theme was brought up in attempt to answer the first sub question. To obtain data about challenges teachers faced with integrating ET for pedagogy the researcher asked the participants if there were barriers, they felt they faced which hindered or made it difficult for them to integrate ET for pedagogy. The following are some of the responses:

> *There is quite a few. One, we do not have internet connectivity in the school. We have Wi-Fi, government Wi-Fi in the school but its only available about a 10-metre radius from the admin block. In my class now I do not have connection to the internet... The other challenge is breakages at the school. Uhm I cannot leave my data projector here hanging on the roof like that. I must take it down every day and carry it home every day. This has increased wear and tear of the machine (**Teacher G).***

> *One of the barriers is the fact that some teachers do not know how to use the technology. So the barrier is that most of the teachers do not know how to use the equipment. That is one of the greatest barriers, and because they feel they have a problem they tend not to use it at all. They just talk through (**Teacher B).***

Like I said only lack of Wi-Fi, then you will be forced to go back to the board, and you have to be prepared ***(Teacher F).***

Yes, we do we have a lot of barriers in technologies with the curriculum. Like I said the curriculum is so stacked up that you do not have the time to really plan technological lesson on a topic because it means to be 1 period then tomorrow you have to do something else again ***(Teacher A).***

It is evident from the response of the teachers that factors affecting integration varied from one individual to another, and from one school to the other. Reasons ranged from erratic Wi-Fi signals to theft, lack of time, lack of technical support and teachers being unable to utilise the technological devices. The reasons stated by the teachers were also discovered by Mentz and Mentz (2003) who concluded that the reasons for poor integration of ET for pedagogy in South African public schools included absence of proper security which led to vandalism, lack of formal teacher training on use of ET for pedagogy, absence of services like electricity and high teacher to learner ratio. So its important to note that despite teachers having knowledge to integrate ET there were other factors that hindered them from successfully integrating ET for pedagogy. Therefore, it can be concluded that its not merely a single factor that affects teachers ability to integrate ET for curriculum delivery, but rather a combination of factors.

The reasons given by teachers for why they were not integrating ET vary from little or no ET at schools, little or no technical support, lack of WIFI, lack of training, shortage of time because of the extensive curriculum demands and lack of time to actually learn about new technologies. Every participant involved in the study was of the opinion that ET has a role to play in mathematics. However, when it came to the Integration of the various ET there were varying levels of integration. In this section, the researcher intends to understand factors that act as barriers on the issue of the integration of ET by teachers.

4.2.1 Poor Infrastructure

Infrastructure refers to the devices and environment that actually allows for ET to be integrated. Voogt and Tondeur (2015) noted poor infrastructure as a factor that discouraged teachers in less affluent areas from integrating ET. Poor infrastructure

may include poor WIFI connection, absence or shortage of computers, absence or shortage of projectors and absence of electricity. Teachers had the following to say about infrastructural barriers they encountered in their quest to integrate ET for curriculum delivery.

> *Well some of the factors would be connection. Wi-Fi connection may be poor or sometimes you cannot actually use the internet and the projector. So you have to research the internet stuff or do your internet stuff before you use a projector in class* ***(Teacher A)***

> *There is quite a few. One, we do not have internet connectivity in the school. We have Wi-Fi, government Wi-Fi in the school but its only available about a 10-metre radius from the admin block. The other challenge is breakages at the school. Uhm I cannot leave my data projector here hanging on the roof like that. I must take it down every day and carry it home every day. This has increased we* ***(Teacher G)***

> *I do not have the technology devices in my class due to theft. (****Teacher B)***

It can be noted from the above that there are many infrastructural barriers that teachers faced ranging from poor WIFI connectivity, breakages and poor technical support. The mentioned barriers made integration of ET a challenge while discouraging teachers from utilising ET for pedagogy. So, it is evident from the data that there is a massive outcry among teachers on the prevalence of poor infrastructure and how it is a factor that is affecting teachers when it comes to integrating ET for pedagogy. When an educator cannot access the internet when he/she wants to use it during a lesson it acts as a detriment for future integration of technology.

As stated by Teacher G above, challenges with the integration of ET for pedagogy includes issues like erratic Wi-Fi connections and theft. Teachers must connect the projector every day and disconnect at the end of each day. This make the process of ET integration very tedious and consumes into lesson time. Consequently, teachers end up opting not to integrate ET. Another common theme that came out was the prevalence of theft in schools. This means that some of the technological devices are not available to teachers. Teacher B perfectly drives this point home as stated above.

Less affluent schools are in areas that are infested with crime. This means these schools are occasionally targeted and broken into. The few ET devices these schools have are then taken by the hoodlums thereby incapacitating the teachers' willingness to integrate ET. Integrating ET means they have to carry the devices in and out of the class whenever they want to use it.

According to (Stols et al., 2015) the reason why educators were not integrating ET for pedagogy in less affluent schools was because of the burden of connecting the technological devices every morning, which in itself, takes time from the ongoing lesson. They further point out that many teachers lack of time was a common problem. Thus, many teachers view ET as a tool that will consume time that they already do not have. This creates an unfavourable view among teachers on integrating ET into classes . ET is supposed to make curriculum delivery less time consuming. Once the use of ET starts consuming time teachers start opting not to use it.

Poor infrastructure is a factor that affects the adoption of ET for pedagogy. Thus, schools in less affluent areas should receive financial aid to deal with situations like breakages and to invest in better security measures. They also need money to replace or fix damaged devices. It is imperative for schools in less affluent areas to be assisted financially to deal with structural problems prevalent in these schools.

4.2.2 Support structures

Support structures include supporting teachers with problems like connectivity, problems with booting laptops and teacher professional development to successfully integrate ET in the classroom for pedagogy. Voogt and Tondeur (2015) posit that one of the key failures of programmes in African countries was the lack of support for teachers' professional development despite schools being provided with technological devices. The issue of support was raised by some of the teachers. Some postulated that they had never been trained extensively on how to integrate ET into the pedagogy. Thus, support is very important in order to encourage the ET integration and change teacher perception on the use of technology. This is very

important as teacher opinion on the importance of ET in curriculum delivery actually plays a major role as to whether the teacher actually integrates technology or not.

> *So here at the school they have not been taking place as I said our ICT committee is not active. Uhm they are all on their own, they do not meet regularly. They are all on islands of their own now. They do not collaborate* **(Teacher H).**

> *I'm fresh out of college, and from my time here there has, not been any training whatsoever. But I heard the other teachers where trained when the lab was built, but personally no, no training has been offered. So, most of the knowledge I picked it up during varsity and we have technology around us so I usually I learn these things as they come along* ***(Teacher D).***

Teacher H showed his distain with the ICT committee and its lack of activity, and how it really did not support teachers to use ET for curriculum delivery. For him, this is the reason why many teachers at the schools were actually not utilising ET for curriculum delivery.

> *Uhm barriers to use technology are the ICT committee is not fully active and not proactive* ***(Teacher H).***

It is then evident from the words of teacher H that the lack of activity and support from the ICT committee inhibited the integration of ET by some teachers. Teacher D also noted that there are no structures for professional development. He stated that that training took place only when the lab was built and nothing, ever since. This means teachers who came after the initial training were not enabled to use ET. If they did not have knowledge of integrating ET for curriculum delivery already, they would have been left to their own devices regarding integrating ET in the classroom. This then brings to the forefront the need for teachers to have a support system to enable them to have their problems addressed. Literature furthers this point by stating that Principals should provide support to the teachers by putting in place measures for professional development (Hayes, 2005). Tondeur et al. (2016) adds to the argument stating that peer support reinforces teacher beliefs and the sharing of ideas amongst teachers regarding ET brings out ideas on how to use ET to support student centred-teaching. Chigona and Chigona (2010) continue to state that they

also discovered that teachers who were supposed to be using ET did not have enough technical support to help them integrate the ET. They asserted that when you needed technical help the technicians would come at their own time, and you simply have to wait for them to show up (Chigona and Chigona, 2010). This derails teacher enthusiasm to integrating ET as they will not be able to use the ET when they want to. As such, the lack of support came as a factor that caused teachers to have little enthusiasm when it came to the integration of ET. This need to be addressed if more teachers are to integrate ET in less affluent high schools in the western cape.

It is important that schools have a fully functioning committee, as this allows for teachers who may not have been previously exposed to ET to get the now how on how to use ET. This point is clearly illustrated by teacher G below.

> *That is how I learnt to use technology. I did not learn through formal training. Whenever I get stuck on something, I approach one of those ICT guys in the committee and ask them how to navigate this problem, and they assist me. And yah, that is how I acquired most of my skills* ***(Teacher G).***

Having support structures for ET integration is critical for teachers previously unacquainted with ET. The importance of such structures was shown by how teacher G learnt to integrate ET for pedagogy despite not having been trained previously to do so. It must however be noted that teacher G first had to see the benefits posed by ET before he decided to learn how to integrate ET for curriculum delivery. This brings to the forefront the importance of a teacher's attitude on whether to integrate technology or not. This means that if a teacher has a desire to integrate ET, they may take all necessary attempts to make sure that they accomplish the goal.

Thus, support structures are important for teachers. These teachers may have a phobia with regard to the use of ET, and having a form of support would help curb any fears they may have. Also, having a system where if a problem arises you can call on experienced personnel to help is important and would encourage more teachers to utilise ET. Therefore, schools need to have a policy on how ET is to be integrated and must have a follow up plan to address the concerns any of the

teachers might have. Once a teacher knows that there is support if they ever need it, they will be encouraged to try to use ET in the classroom for pedagogy.

4.2.3 Teacher beliefs on the importance of ET for pedagogy

Teacher belief refers to the beliefs teachers have about the importance of ET for pedagogy. It refers to the influence these beliefs have on the teachers decision to integrate ET for pedagogy. If a teacher believes ET has advantages in the teaching of mathematics he/she will go out of his/her way to learn how to use the technology effectively. But if the teacher feels he/she does not benefit from the use of ET they will not integrate ET in their classroom for pedagogy. Literature supports this notion with Leendertz (2013) postulating that to fully understand ET integration teachers' pedagogical beliefs have to be taken into account, This is further supported by Marcinkiewicz (1993) who points out that there is a need to study teachers and understand what makes them integrate ET if we are to get full ET integration.

It is important to understand that even if schools are equipped with ET the role of the teacher who must integrate the ET must be understood. If we have teachers who feel ET is not important, or that ET is a distraction then getting full technology integration may not be realised. However, according to the NDP mathematics education is a national priority in South Africa. ET is seen as a tool that can be used to increase learner performance in this subject (Stols et al.,2015).

> *Everything is technological these days. So, you see the computer makes things better like I said, and they will understand your topic much better and then (Uhh) like I said it will also improve your lesson and will make you more up to date with technology (**Teacher C).***
>
> *Go hand in hand, that is true yes. The teachers stuck in the old chalk and board cannot get similar results with someone using technology. I do not think so, you know **(Teacher E).***
>
> *If it is used optimally it has the potential to make a difference in learner performance in mathematics. It all depends on how you use it, because technology is there to make our lives easier and technology is going to be here forever. So, there is no way we can run away from it. We have to embrace it. It is here to stay. I can see for myself since I started using technology, I can see that even my teaching has improved and consequently that rubs off on the learners as well. Their level of understanding seems to be improving by day, but it is not an overnight thing. It is a process **(Teacher G).***

We can see from the above comments from the teachers that they believe that ET has a role in the teaching and learning of mathematics. Teachers state that ET was beneficial as it helped make their lives easier, helped improve the quality of teaching, helped improve learner results in mathematics as learners would have been taught more efficiently using ET. All of the teachers who were sampled for the study believed that ET helped make their lives easier, and that it was the future for teaching mathematics because of the numerous benefits it posed.

What was interesting to note was that despite all teachers having a positive view on the role of mathematics in the classroom not all teachers integrated ET. This was as a result of various factors that were outside the teachers' control like lack of training, lack of support, absence of ET devices or theft. So, despite teachers having positive attitudes towards the integration of ET for pedagogy these factors still hindered them from integrating ET for pedagogy.

> *To learn at their own pace is definitely the main advantage. Also, to see a different point of view other than my own. So, there will be a different take on it. Maybe they did not get it when I explained. Maybe they will when someone else. You offer the learner various points of view and hopefully that will be something that they build up (**Teacher I).***
>
> *Learners can only benefit from technology as it allows them access to problems, explanations, and methods beyond the classroom borders **(Teacher E).***

Teacher I and Teacher E clearly hold the position that ET has advantages and benefits. These range from allowing a different voice to teach learners by means of a video, and allowing learners to have different points of view on a topic. Despite having a positive attitude towards ET, Teacher I and Teacher E did not integrate ET in their classrooms. The following were their reasons:

> *I do not have the technology devices in my class due to theft, however I am very willing to use it as I can see the need to keep up with the new methods of teaching that involve technology **(Teacher E).***
>
> *Here we do not have Wi-Fi so we cannot uhh display everything on YouTube or anything like that. I'm a bit limited umm I have to get the*

projector out of my own pocket. And, umm I do not know how I'm going to get it installed. That is another story but we will figure this out because I think my projector is almost here ***(Teacher I.)***

It is evident from the above that despite these teachers having a positive attitude towards the integration of ET they were limited by external factors such as theft and unavailability of ET devices at the schools were, they taught. This bring a very important discovery. Teacher beliefs are very important regarding the integration of ET for pedagogy as concluded by Polly & Hannifin (2010). Teachers' attitude and beliefs play a determining role in the integration of ET in the class. The results in this study prove that most teachers do admit that ET does have a role to play in mathematics education. However as in the case of teacher E and I other barriers such as theft and unavailable ET made it impossible for them to integrate ET for pedagogy in their classrooms.

Therefore, these teachers had the right belief about the use of ET but because of poor infrastructure they were not able to integrate ET. This was not the only reason as teacher E further noted that she did not use ET because she was stuck in her olden ways and the results, she got from these traditional teaching methods.

I have not expanded to the use of technology because I am stuck in my old ways and the results I get from it ...but I am open for the incorporation of technology ***(Teacher E).***

Teacher E had a positive attitude towards ET but factors like theft and being stuck in her traditional teaching prevented her from integrating ET. This means that when looking at the integration of ET for pedagogical use it is very important to look at the whole spectrum. As much as the teacher's attitude plays a role on his decision to integrate ET, there are other factors that can influence his decision to integrate ET, or not to, like theft or poor infrastructure. All these issues must not be dealt with individually, but wholesomely so that teachers can work in environments that encourage the integration of ET for pedagogy. It is important to train teachers to use ET. It is important to show them the benefits ET has and it is important that these

schools have the ET which is properly secured. If all these things are effectively implemented, then chances of integration of ET for pedagogy are greatly improved.

4.2.4 Lack of training on integrating ET for teaching mathematics

Lack of training refers to absence of formal training at university or teacher training institutions on how to effectively integrate ET for pedagogy. It also refers to workshops that can be held at schools to make teachers aware of the various ET available and showing them also how to effectively integrate them for pedagogy. A common thread that also came out during the interviews was the lack of proper training on how to use and integrate among teachers. Those teachers who had not received proper training were as a result not confident enough to integrate ET in their classrooms. Hayes (2005) agrees with the above statement on the importance of training and states that Principals should provide support to teachers by putting in place measures for professional development. He continues to state that it is important to offer support to teachers, and to also have structures such as an ICT plan and ICT training (Hayes, 2005). Teachers' responses are noted below on whether they had received training on integrating E for pedagogy.

> *Not really, thorough training was only for over a period of just one session, not many! I have forgotten most of what I have been taught* ***(****Teacher* ***E).***

Teacher E, who did not integrate ET for pedagogy, said she had not received adequate training regarding the integration of ET for pedagogy. She stated that there was just one session she attended, and she did not remember most of what had been taught there. So, teacher E had low confidence in using and integrating ET, and as a result she did not integrate ET for pedagogy. This shows how important it is to train teachers to effectively integrate ET for curriculum delivery. Chigona (2015) discovered in her study that newly qualified teachers were not integrating ET due to poor training they received during their teacher education. It is important to train teachers to effectively integrate ET for pedagogy. Once teachers know how to integrate ET, they will have the confidence to implement it in the classrooms.

Without TK, teachers will not be able to effectively use and integrate ET for curriculum delivery. Possession of TK is important in order to achieve integration of various forms of ET. If teachers have a high level of TK then it logically follows that these teachers will integrate and utilise ET in their pedagogy. This is driven by their high levels of confidence when using ET. Teacher self-efficacy is an influencing factor in the integration of ET (Tondeur et al., 2008). Literature also supports the idea that a teacher's self-efficacy with technology use plays an integral role in their integration of technology.

The more confident a teacher feels with using technology the higher the probability that he/she will actually utilise ET. Buabeng-Andoh (2012) states that teachers' self-efficacy has great influence on the integration of ET. Leendertz (2013) says that lack of confidence is a barrier to ET integration in mathematics classrooms. Therefore, boosting the confidence of mathematics teachers will result in the teachers becoming enthusiastic and more interested in embracing ET for curriculum delivery. Chigona (2015) agrees with the above positing that teacher efficacy influences whether he/she integrates ET in his/her classes. She further adds that teacher efficacy influences their technological efficacy. Chigona concluded that if a teacher was never trained to use ET that affects their teaching and generates low self-efficacy to integrate ET into the classroom (Chigona, 2015).

The overwhelming positive feedback on the influence of self-efficacy on the Integration of ET, and the findings of this study show the importance of teaching teachers on how to use ET, and using it properly at a high level. In order to develop a positive self-efficacy among teachers it is therefore important that during teacher education aspiring teachers are equipped with the necessary skills to be able to integrate ET in the classroom (Chigona, 2015). A teacher with a positive self-efficacy will feel confident enough to be innovative and creative in the classroom (Chigona, 2015).

Most of the participants in this study possessed limited ICT skills. The majority of the participants only used ET in the following ways: PowerPoint presentation, word processing, internet, WhatsApp, emails, overhead projectors, photocopying and scanning. In his response on how he used ET teacher B said the following:

Yes, I do. I do I do. (Umm) As you notice the papers I set up on laptops and computers (Uhhm) class work should be on an interactive board. Now this is not an interactive board. This is just an ordinary whiteboard, are you with me? So, I put the cable into the computer, and I play the work from the computer and show the syllabus of the work to the kids ***(Teacher B).***

It is evident as far as teacher B was concerned that using ET was merely setting question papers using MS word and displaying work on the board. The skills to use ET, though limited for some, were obtained in various ways. For some these skills were acquired in university during teacher education, and for some they were obtained on the job. Teacher C stated the following responding to whether he had been taught to use ET in teacher training a university:

From varsity, they explain it. There is actually courses where they explain how to use the smart board and that. So ya we got training from varsity already ***(Teacher C).***

A number of teachers, though admitting to have somewhat been trained to use ET, were of the opinion that they needed some more specialised training. As observed, most teachers referred to using ET as merely using PowerPoint presentations in teaching, and this state of affairs calls for further continuous and intense training on using ET for our educators.

Only two of the 9 interviewed and observed teachers (22%) were using ICT in ways other than PowerPoint presentations. These teachers were effectively using ET to enhance learner understanding. Educational software's like the Hatfield online school and plickers were used to give learners a different angle to learning. What came out of the study is the incredibly low number of teachers that have high ET efficacy, and that actually use it effectively. This necessitates the need for additional ICT training.

It was evident from the observations carried out by the researcher that many teachers had good PK, CK and good PCK. However, when it can to integrating technology the TCK was lacking as the ET was being used merely as a substitute for the traditional chalkboard. As previously stated, technological skills alone do not guarantee a teacher's ability to teach effectively with ET. For a teacher to be able to

utilise ET efficiently and effectively in the classroom the teacher must be in possession of the following types of knowledge that were discussed in more depth in chapter 2. The types of knowledge are Technological Knowledge (TK), Content Knowledge (CK) and Pedagogical Knowledge (PK). For effective integration and use of ET, a teacher would need to be in possession of the three above knowledge types and have the ability to use them effectively and efficiently as one.

The 9 participants in this study had the following to say when asked if they had received enough training to utilise effectively, and if they actually integrate ET for curriculum delivery.

> *Remember I was at varsity 30 odd years ago, where there was no cell phones and nothing like that. So uhm the software was given to me and they basically trained us, the people who gave me the software they trained me and my teachers to use the software you know and obviously it gets easier over time. Once you have software, technology. You find other ways to incorporate you know what I mean* ***(*Teacher F*).***

The above response is evidence as to why it is important to train teachers to utilise ET. Teacher F, though not having any formal training on the use of ET, was trained to use ET and now uses ET every day for his curriculum delivery. The conclusion that the researcher reached was that for teachers to integrate ET teacher knowledge of using ET that is gained through training is of the utmost importance.

Despite receiving training on utilising ET some teachers are not utilising ET in their curriculum delivery as previously discussed. This trend is supported by literature as noted by Chigona and Chigona (2010), in their study looking at ICT integration in the Western Cape. They noticed that not many teachers were incorporating ET in their classes despite having received training through the Khanya project. They continued to state teachers were still uncomfortable utilising ET in their classes signifying that the training they received was inadequate. The participants in this study reiterated the statements above by stating that they felt that they needed additional training to fully integrate ET in their mathematics classroom.

Training was noted as something that was really needed as the researcher noted that some teachers were only learning how to use a computer to type examinations and assignments. Something so basic was a novelty to some of the older teachers. This alone showed the need to train teachers to utilise ET with specific attention to mathematics. Teacher B, with the most experience of 40 years, had just learnt how to type examinations and inserting equations on Microsoft word. This shows he was still a novice as far as technology was concerned. You cannot therefore expect such a teacher to be able to fully integrate ET for curriculum delivery as it is understood he will not be able to do so.

Teacher E, with 15yrs of experience, claimed not to use technology at all as she was stuck in her olden ways of teaching which produced the results. However, the younger teachers who were fresh from university claimed competency in using technology. This trend goes along with what was found by the U.S National Centre for Education Statistics (2000) which stated that teachers who had been teaching less years used computers more than teachers who had been teaching for longer periods.

The trend noted in this study, however, contradicts the findings by Buabeng-Andoh (2012 citing Lau & Sim 2008) who in their study discovered that younger teachers were integrating ET less as compared to their experienced counterparts. Also contradicting the results of this study is Chigona (2015) who discovered, in her study, that while newly qualified teachers are expected to integrate ET anecdotal evidence shows that not many are successful due to poor training from their teacher education. The conclusion was that teachers are qualifying without the specialised skill needed to incorporate ET into their classrooms.

Buabeng-Andoh (2012 citing Bebell, O'Dwyer, & O'Connor 2003) continues with this line of thought stating that the reason why older teachers were using ET more as compared to younger teachers is that new teachers' focus was more on how to utilise the ET instead of how to incorporate it into the teaching. Additionally, in their first few years of teaching younger teachers spend most of their time getting acquainted with the school's curriculum and working on classroom management skills (Buabeng-

Andoh, 2012 citing Bebell et al., 2003). Buabeng-Andoh (2012) further clarified that additional factors that encourage confidence in the integration of ET are having time to practise integrating ET and training on how to effectively use them.

As aforementioned, training is very important as it equips teachers with the ability to use and integrate ET for curriculum delivery. Nkula & Krauss (2014: 245) summaries the significance of educators being exposed to various forms of ET that address technological and pedagogical needs. The driving force behind this thinking was that the willingness of teachers to utilise ET has been noted to be driven by teacher's ability to use ET. Ndlovu and Lawrence (2012) are of the opinion that teacher training that properly equips teachers to use ET must be advocated for. They emphasize the importance of training surrounding the Technological Pedagogical Content Knowledge (TPCK) as it encourages an efficient integration of ET for curriculum delivery.

Results emanating from this study are pointing to the fact that proper training is lacking amongst teachers in less affluent high schools in the Western Cape. As per the responses from the teachers there is no professional development positions being taken by these schools to train teachers to be efficient users of ICT. One of the schools did have an operational ICT committee but it was not effective in training teachers There were positives, however, as if a situation arose where a teacher had interest and went to ask questions, they were willing to offer help.

As has been the common thread on all of the themes in this study, solving one issue alone may not be enough to solve the problem of teachers not integrating ICT for curriculum delivery. This will however, be a step in the right direction. Nkula and Krauss (2014:245) assert that even though some teachers had received professional development training on the integration of ET, meaning they had the skills required to integrate these technologies, they still showed no interest in integrating ET for curriculum delivery. This shows that sometimes it is a combination of factors that prevent teachers from integrating ET in their classrooms.

4.3. Advantages of integration of ET for curriculum delivery

This theme dealt with how ET made it easier for teachers to teach or plan for their lessons. It focused on the positives ET brings about to curriculum delivery. Watson (2015) is of the opinion that ET like the Interactive Whiteboard (IWB) provide teachers with various ways to make lessons creative and exciting for the learners. Findings from this study also go hand in hand with literature as all teachers who were sampled in this study agreed that ET had a positive role to play in mathematics education. Additionally, teachers agreed that ET promoted engagement in the curriculum delivery process. They agreed ET grabbed learner attention and encouraged learners to be active participants in the classroom. Also, teachers agreed that ET made the teaching process easier, and helped lighten the work load.

> *"Technology has a role to play yes; it can be used to increase student achievement. But we must be realistic it is not always the best option; sometimes teaching without it is the way to go. So, it is not like it is the Holy Grail that will solve all our problems and make learners start taking school seriously. But when used effectively it does wonders. It definitely grabs learner attention. And by that learners are willing to learn more. For instance, coming to the smart board and writing down answers there is just raises leaner interest in the subject as learners would like to come to the front and work some sums out* ***(Teacher D).***

> *(Uhh) well it enhances the lesson in terms of speed it can speed up the explanation process so that you have more time to have practical work for the learners* ***(Teacher A).***

> *To learn at their own pace definitely the main advantage also to see a different point of view other than my own so there will be (stuttering) a different take on it maybe they did not get it when I explained maybe they will when someone else. You offer the learner various points of view and hopefully that will be something that they build up* ***(Teacher I).***

From the responses of the teachers above we can see that they were all of the opinion that ET made their lives easier. Teachers mentioned advantages like grabbing leaner attention, providing learners with a different learning perspective and helping the teacher increase the rate at which they cover content. ET integration

provided simplification to teacher's daily routines. Jhuree (2005) supported the findings of this study by positing that ET also had a capability to make life easier as it made instruction easier, thus easing the burden on teachers who already have a lot on their plate. It is no secret that teaching is a stressful job that requires a lot from the teachers involved. So if technology promises to make these duties easier for the teacher they would be more willing to integrate technology in their classes

Benefits like making administration duties easier and allowing engagement for learners make teachers more open to integrating and using ET for curriculum delivery. For instance, a teacher can use ET to enlarge the classroom by allowing learners to communicate with their teachers using applications like whatsapp. Application like whatsapp allow learners to easily communicate with their teachers nomattter were they are. This is an example of a benefit ET provides for the teacher. This feeling is supported by literature as Jhurree (2005) found out. She concludes that ET is an extremely useful tool for dealing with administrative tasks for teachers. She further goes on to say that ET allows for an inclusive environment that is needed especially areas where learners come from various socio-economic backgrounds. ET thus can provide the means of promoting equal access to education (Jhuree, 2005). ET is a tool that allows learners to have access to information despite them being away from the classroom.

Teachers had more to say about the advantages posed by ET.

> *Firstly, you can use it to gain learner attention you know, and if you are to make learners come and write things on the board it will definitely up their curiosity and this will cause them to be more interested in the subject matter. Smart boards, you can write your answers directly on the question paper, save it and use it again next time. It just simplifies your life if you know what I mean. Oh and there is this software I heard of where u can show a 3d shapes and you can move it around so learners can see how many sides the shape has. There is just many possibilities when it comes to ET man, you know. You just gotta know how to use it and implement it (**Teacher D).***

The statement above illustrates that teacher D Integrates ET in his lessons because of the educational advantages the ET poses and how it brings about a deeper

understanding for the learners. Teacher D admits that ET brings about learner curiosity, meaning ET makes learners to be more interested in school. Thus, teachers would integrate ET for curriculum delivery in order to spike learner curiosity and consequently grab learner attention during the teaching and learning process.

ET also helps learners who are visually oriented to perform well and excel in their school work. Visual learners are not interested in the traditional chalk and talk and perform better when images and videos are used. Teacher B posits that the reason to use ET is its ability to make life easier. He goes on to say how exposing learners to ET may enable their own curiosity to want to use technological devices. HE further adds saying the following.

> *Well it firstly changes the methodology of the subject to the kids. It introduces a different way of teaching a certain method to solve the problem and it changes the child focus area from the boring blackboard work they now see interactive media being shown by the computer so there is a change, you constantly change the child's approach to mathematics by using these apparatuses.* ***(Teacher B).***

Teacher B obviously possesses TPK as he admitted that the methodology changed based on the ET being used. His reasons for integrating ET were that it introduces a different lens to teaching while additionally making lessons more interesting. Moreover, he noted the ability of ET to make lessons more interactive which in turn encourage learners to construct their own information instead of bring passive recipients of information. These results are also supported by literature as averred by Watson (2015) who is of the opinion that technological features such as photos, sound, animations and video are elements encourages learners to learn and in the same vain enhance teaching by capturing and maintaining learners concentration. They further add on to this by saying that visual learners benefit from good visual resources like pictures and videos. In light of this, ET like Interactive Whiteboards enable lively, exhilarating lessons, drawing from videos and animations from different sources. Therefore, with various ET like the Interactive Whiteboard (IWB) teachers are finding various ways to make lessons creative and exciting for the learners (Watson, 2015).

We can see from the above that videos and pictures enhance teaching and captures learner interest by making lessons more interactive. ET stimulates visual learners as well as learners with educational barriers. In responses to benefits like this, teachers are thus influenced to use ET in their classrooms.

Teacher C shares the sentiments of teacher B by stating how ET helps learners understand concepts better. Another thing to note is learners develop a love for computers if they are exposed to them. However, if the teachers themselves do not use computers this may prevent the learners from also having an interest in using or learning about computers.

> *Everything is technological these days so you see the computer makes things better like I said and they will understand your topic much better and then (Uhm) like I said it will also improve your lesson and will make you more up to date with technology so the learners who can see when you use me using a computer screen and enabled them to become more how do you say computer literate to be discipline and doing computers and keep up with technology* **(Teacher C).**

Additionally, many educational institutions have begun a process of incorporating the latest ET in order to provide learners with a superior learning environment. The pushing factor behind the widespread integration of ET lies in the ability of ET to raise and transform teaching and learning to higher levels, and bring about a transformation in the education process by increasing learner engagement (Fu, 2013). Furthermore, another reason why ET integration is so widespread is that incorporating ET in the classroom raises teaching and learning to new levels (Somyürek, Atasoy & Özdemir, 2009; Higgins, 2003). Bester and Brand (2013) concur with Somyürek et al. (2009) and Higgins (2003) arguing that integrating ET encourages learner-centred learning and provides teachers with options to develop skills like comprehension and problem solving in their learners.

Murcia (2010) avers that ET initiates a means for the development of interaction and dialogue among learners. Dialogue and interaction are developed by the inherent nature of ET to create a learner-centred teaching environment. A learner centred teaching environment allows for the creation of an environment where learners are subjected to working together during activities like group work, and by so doing

developing learners' dialogue and interaction. Warwick et al. (2010) further added that ET provides an instrument and an environment that encourages dialogue and knowledge construction among learners When learners are involved in the learning process they enjoy as learners will not be merely passive participants in the lesson. As such Hall & Higgins (2005) found that both teachers and learners report that ET use in education makes lessons enjoyable.

Despite ET possessing several benefits as listed in this section there was still a large number of teachers who were not using ET and the reasons as previously discussed range from poor infrastructure, lack of training and negative beliefs on the role of ET in curriculum delivery. It is therefore a combination of factors that have to be addressed if we are to see teachers integrating technology for teaching and learning.

4.4 Summary of chapter

In this chapter, critical factors affecting the Integration ET by teachers in less affluent areas were dissected and outlined. It was very evident from the results that despite the acknowledgement of the benefits ET provided to pedagogy teachers faced a number of factors which hindered their Integration of ET for pedagogy severely. These factors include lack of support, lack of infrastructure and lack of adequate training, theft, low technological efficacy and lack of support structure at schools. These factors along with many others are some hindrances that came out in this chapter that are affecting teachers in less affluent areas from fully integrating ET for pedagogy. In order to achieve the perfect integration of ET there is need for plans to be put to rectify these hindrances. This is the only way schools in less affluent areas of the Western Cape will be able to have full integration of ET for pedagogy.

In the following chapter, conclusions drawn from the research findings are presented leading to some recommendations.

Discussion of findings and Conclusions

The purpose of this qualitative study was to identify factors affecting the integration of ET in less affluent high schools in the Western Cape. Through the use of interviews and observations, the researcher shed light on individual teacher's feelings on ET integration for pedagogy and the reasons why teachers chose to integrate and use ET, and/or the reasons why they chose to stick to the traditional paradigm of teaching. This chapter focuses on the discussion of major findings that came out in this study as related to literature on ET in mathematics education and the integration of ET by teachers. Also included in this study is the connection between the theoretical framework and the major findings. In conclusion, the chapter will discuss the limitations of the study, areas for future research, and a brief summary.

Included in this chapter are discussions and future research possibilities to answer the following questions**.**

The key questions that are guiding this study are:

What are the factors that affect the Integration of ET by mathematics teachers for pedagogy in less affluent High Schools in the Western Cape?

Sub-questions

1. What challenges do mathematics teachers have with the Integration of ET for teaching and learning?
2. What do mathematics teachers perceive as the benefits of using ET for curriculum delivery?

A qualitative approach was used in this study, and it successfully met the objectives of the study that are listed below. A qualitative approach was believed to be the most suitable as it stayed within the realms of the study's theoretical framework. By utilising this approach, the research questions were answered, and the objectives were also met.

The objective of this study that emanate from the aim of the study are:

- To identify and analyse the factors that influence the integration of ET for pedagogy in mathematics classrooms of public schools in less affluent high schools.
- To understand challenges that teacher face with the integration of ET for pedagogy in their mathematics classrooms.
- To provide possible recommendations for high schools in less affluent areas of the Western Cape on how to address challenges associated with the integration of ET for pedagogical use in mathematics.

The rest of this chapter is organised into subsections as follows:

5.1 Summary of findings

5.2 Recommendations and suggestions

5.3 The researcher's final remarks

5.1. Summary of the Findings

This study intended to investigate factors affecting the integration of ET for pedagogy by mathematics teachers in less affluent high schools of the Western Cape. Findings revealed a multiple set of reasons that influence the integration of ET for pedagogy by mathematics teachers. These range from poor infrastructure, lack of support, lack of training and theft to name but a few. These reasons and themes are discussed in more detail below.

5.1.1. Teacher familiarity with the integration of ET

This theme focused on teacher's familiarity with the use of ET for pedagogy. The aim was to determine if teachers had been exposed to teaching with ET either during teacher training or at their current or previous workplaces. It was also reported from the findings that teachers' familiarity with ICT was very influential regarding the teacher's decision to utilise ET for curriculum delivery. The older teachers according to the finding were not trained to integrate ET for pedagogy during teacher training. This was because 20 or 30 years ago computers were fairly new and basically non-

existent in Africa. This then meant they graduated without being exposed to computers or any ET. Most of these teachers only started getting exposed to ET recently when ET started infiltrating the educational sphere. So, this then meant these teachers had to learn about ET on the job. Having gone so long without using ET made some of the teachers reluctant to learn something new even though they were very much aware of the educational benefits these technologies had.

It was also reported from the findings that teacher's familiarity with ICT had an influencing role in the teacher's decision to utilise ET for curriculum delivery. Many older teachers reported not having been trained to use ET in teacher training and this seemed to affect many teacher's willingness to actually learn and integrate ET in their classrooms. Despite teachers receiving training on how to use ET with the launch of the Khanya project, the findings seemed to show that the workshops were not done in depth, and were not specific to the subject matter. This resulted in many teachers having low self-efficacy when it came to the use of ET. Many still felt they needed more training on how to utilise ET for curriculum delivery. Younger teachers were more open to using ET due to them having received training on how to use the apparatus during teacher training. However, receiving training alone did not mean teachers would use ET in their classes as was reported in the findings. Integration of ET was influenced by a various set of factors, which included but not limited proper technical support, availability of resources and security of the ET apparatus.

Incompetency in ET integration was partly influenced by the way educators were taught by their lecturers during teacher training. The ultimate effect of this was poor technological knowledge, technological content knowledge, technological pedagogical knowledge and technological pedagogical content knowledge, among mathematics teachers in these less affluent high schools. In order to encourage more mathematics teachers to integrate ET for curriculum delivery and to improve their competency with integrating these technologies teachers needed more hands-on experience during teacher training. Therefore, there is need to train more teachers on how to use ET in their classes. Firstly, during teacher training the use of ET must be emphasized, and also after teachers are qualified there must be mandatory workshops that keep teachers up to date with what is happening in the ET field and train teachers on how best to use these new developments to equip learners.

None of the teachers was in possession of TPACK. Considering that a large number did not even have TK it would be far-fetched to expect the same teachers to have TPACK. Basing again on the poor training regarding ET, many teachers were found lacking concerning TK, TPK, TCK and TPACK. As such, in order to have fully-fledged teachers who possess TPACK there is a need to firstly focus on the basics, TK being primarily of concern.

It is therefore the researcher's conclusion that teacher familiarity to ET influences teacher integration and use of ET for pedagogy. Exposing teachers to technology makes them comfortable around it, and when it comes to the classroom, they will not be scared to integrate ET for pedagogy. There is need to train teachers regularly so those without prior experience with ET can be given a chance to start learning how to integrate ET at their own pace. Teachers have to be made familiar with technology and they need to be made comfortable with ET. Only then will we experience full ET integration for pedagogy in less affluent high schools in the Western Cape.

5.1.2 Teacher challenges with the integration of ET

Teachers face many challenges or barriers with integrating ET for pedagogy. Challenges ranged from poor infrastructure, lack of support to the teachers, lack of training to integrate ET and low technological efficacy. Poor infrastructure included lack of ET apparatus due to financial problems, theft of ET apparatus at the schools and erratic Wi-Fi connection. These difficulties made teachers to negate the use of ET and use the traditional teaching methods that did not need any technical support.

Some schools simply did not have a strong enough Wi-Fi connection meaning you need to be at a certain range from the office to get a connection. This meant teachers who had classes further away from the offices could not utilise the Wi-Fi during their lessons. This gave teachers extra work of pre-downloading material, and this extra effort discouraged some teachers from using this technology to be an integral part of their curriculum delivery. Another barrier that came up was there was no structure to effectively assist teachers who had any issues with the technological

devices in their classrooms. When dealing with older teachers who are still novices with ET integration, there is need for a strong support system which was unfortunately not present at these schools. Such situations discouraged teachers from integrating ET for pedagogy. There is a need to address these barriers if less affluent schools are to have teachers who are in possession of TPACK.

It is utterly evident from the results obtained in this study that many of the educators in the sampled public schools had limited, and in some cases, non-existent abilities to integrate ET in their classes. Many reasons can be attributed as a cause as to why there was such a low aptitude on the Integration of ET by mathematics teachers. The observations and interviews showed that many of the teachers were at the *entry* stage, which according to Ndlovu & Lawrence (2012) shows teachers' abilities to use ET as being limited to using ET for interaction. It was therefore very clear from the findings that despite teachers' understanding and appreciating the value that ICT posit the reality on the ground is there are many challenges faced by these teachers that are putting a dent in the teacher's desire to integrate ET for curriculum delivery.

Observations were explicit in showing that there is a long way to go before full ET integration can be realised. From the lack of ET devices to teacher inability to operate ET, the researcher observed there is a need for many structures to be out in place if we are to have full ET integration. Teachers need support in terms of training, in terms of technical support, there is a need to have a whole school ICT plan that outlines how ET must be utilised, and this will then go a long way to encourage integration of ET among teachers.

Analysis of present data showed that none of the teachers was in possession of TPACK. None of the teachers from the observations conducted could seamlessly integrate ET in a way that showed the teachers possessed all 7 constructs of the TPACK framework. It is also very important to point out that though some teachers had a vast knowledge of computer applications, and various ET that could theoretically be used for curriculum delivery many of these teachers lacked the technical skill on how to amalgamate their TK, CK, PK together with the other types of knowledge to create successful integration of ET for teaching and learning. It is therefore to the researcher's contention that that teachers need to be furnished with

skills that would enable them to combine the 7 constructs of the TPACK framework which are necessary for the effective Integration and use of ET in curriculum delivery. It is therefore the researcher's conclusion that the many challenges teachers face influences the decision of whether teacher integrate ET or not. When ET integration for pedagogy is surrounded by many problems, these problems act as hindrances for teachers to Integrate ET for curriculum delivery. There is a need to address these barriers if we are to experience full integration of ET in mathematics classroom of High Schools in the Western Cape. Schools must have effective ICT support structures to help teachers with any IT elated challenges. Schools must be financially assisted so they can increase their Wi-Fi reliability and strength. Safety measures must be implemented to safe guard the ET already at these schools. Once these concerns are addressed an environment that encourages the adoption of ET will be created, and the uptake of ET integration will surely increase.

It has been concluded from the findings that these challenges do affect the integration of ET for pedagogy. These challenges affect integration independently and combined. So, solving one challenge does not necessarily mean integration will increase. You may provide support structures to ICT problems but if ET devices are not available there will not be integration taking place. All challenges experienced by teachers need to be dealt with, and in so doing an environment that encourages the integration of ET for pedagogy will be created.

5.1.3 Advantages of integration of ET for curriculum delivery

It is paramount to point out that the researcher found out that all participants in this study were of the opinion that ET had a very big role to play in the mathematics classroom . Despite some teachers not being avid to the integration of ET in their curriculum delivery, they were all in one accord when describing the benefits that ET had over traditional teaching. Some of the benefits that teachers described included the ability of technology to save time since all teachers agreed the curriculum was packed and left no breathing space. Teachers also agreed that that technology had the ability to change the way information was presented and allowed for different media like videos to be played in order to provide learners with a

different perspective. Therefore, all teachers agreed on the importance of ET in the classroom and agreed it had the potential to simplify their lives. However, even considering such positive remarks on the use of ET some teachers still did not use ET in their classrooms. The reasons differed from teacher to teacher but after the analysis of present data the researcher concluded that there was not one factor that individually affected the integration of ET in the classroom. The integration of ET by teachers was influenced by a number of reasons, and it was a combination of these that was the main cause behind the lack of integration of ET by some teachers.

It is the researcher's conclusion that all teachers were of the opinion that ET was very beneficial for pedagogy. It provided ease in doing tasks and allowed for the class to be extended beyond the classroom. Teachers need the challenges mentioned prior to fully integrate ET as they are fully aware of the advantages ET poses.

5.2. Recommendations

Looking at the findings of this study has necessitated the following recommendations. Firstly, there is a need to encourage the integration of ET in less affluent schools in the Western Cape and to increase efforts that encourage the development of TPACK. Mathematics teachers need to be provided with more ways to gain knowledge of how to integrate ET into their classrooms. It should also be encouraged that mathematics teachers design lessons that integrate ET, then teach these lessons to their colleagues before teaching students. Feedback from their colleagues must be given in a friendly environment to encourage teachers with low efficacy with the integration of ET to feel confident enough to try and use ET in their classrooms. This method would prove reliable as critiques from their peers would help teachers to fix their mistakes and perfect how they use ET in their classes before they actually teach the learners. Critiques from colleagues is a reliable means to encourage successful teachers' development of TPACK.

It was found out that from this study that though teachers had undergone training on how to integrate ET in their classrooms for pedagogy they were not competent enough when it came to integrating ET for curriculum delivery in the mathematics

classroom for any given pedagogical approach. Thus, further training sessions must be conducted on regular intervals to encourage teachers to keep abreast with technological updates and to train teachers to be in possession of TPACK. Regarding the training conducted by the WCED it came out during interviews that it was generic and needed more emphasis on being particular to didactics instead of being generalised. When teachers are trained how to use ET for their subject matter, it will encourage more and more teachers to want to use ET and this aids in the development of their TPACK.

When attempting to increase the integration of ET it is very important to note that there is no integration without the availability and accessibility of ET apparatus. There has to be available ET in the school, and it must be functioning optimally and well managed before we can start thinking about teachers successfully integrating these ET in their classrooms. Teachers' motivation to integrate technology with pedagogy and content can be enhanced by the presence of different learning support technologies. Several teachers complained of erratic and slow Wi-Fi connections. This acts as a detriment to teachers' desire to integrate ET. When installing Wi-Fi connections, the WCED must make sure the Wi-Fi covers the whole school, and that it has steady signal strength with acceptable internet connection speeds. Just having structures like this working optimally puts more confidence in teachers allowing them to attempt to use ET and thus beginning the step to being in possession of TPACK.

Another critical component to note is that the development of TK, PK and CK and the relationship between PCK, TCK and TPK to form TPACK requires ET apparatus to be available, and of utmost importance is teachers' motivation to integrate the three components. Leendertz (2013) suggests that the role ET plays in a classroom is strongly linked with teachers belief about the nature of teaching and learning. So this shows that teachers must be motivated to use ET they must see the benefits ET posits, and an environment that encourages them to use ET must be created. Teachers must be motivated to integrate ET in their curriculum delivery and only then can thy develop their TPACK

5.3. The researchers' final remarks

The integration of ET in mathematics classrooms of less affluent high schools in South Africa has the potential to promote effective curriculum delivery in the classroom. This is important in schools that have limited resources and have a track record of learners performing poorly. The researcher is convinced beyond doubt that for the integration of ET in mathematics classrooms of less affluent high schools to gain traction it is very important that all stakeholders identify factors that discourage teachers from integrating ET, and put measures to address the shortcomings. At the same time, it is very important to identify factors that encourage mathematics teachers to use ET so that an environment that encourages the integration of ET may be made prevalent in more less affluent high schools. As has been identified in this study that its usually a combination of factors that dissuade teachers from using ET thus it is of the most importance that these be addressed. It is very important that schools have functioning ICT committees as the findings pointed out that many teachers view ET in a positive light but have poor self-efficacy as such the ICT committee can go some way in addressing that issue.

In conclusion, this study used a small sample of mathematics teachers from two less affluent high schools. It used interviews and observations as data collection instruments. Another study with a sample of students and more teachers from various schools is needed. For a more in-depth picture on what hinders and what promotes ET integration in mathematics classrooms there is need for a study that will involve a larger sample of teachers and schools. A larger sample will in turn provide a better opportunity for instituting a connection between TPACK and technological skills, TPACK and technological tools and TPACK and teachers' readiness to use ET. The proposed study should incorporate mathematics teachers, school administrators, ICT support team and mathematics students.

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Appendix A: Interview schedule: Data collection instrument 1

This interview schedule is for educators and is aimed at establishing factors affecting the Integration of ET for pedagogy in less affluent High Schools in the Western Cape.

1. Do you have enough technical skill to use technology in your class?
    - If yes, do you utilise technologies in your pedagogy
    - If not, why don't you
    - What factors influence your willingness to Integrate technology in mathematics classrooms?
2. Were you taught how to integrate technology into your teaching?
3. What technologies are at your disposal and how often do you use them and why?
4. Are there provisions for professional development regarding teaching with technologies considering the pace at which technologies are changing?
    - If so, what are they? How have you benefited from them?
    - If not, how do you keep up with the constant changes in technology on a personal level?
5. What are you doing individually for your own personal development on technology integration?
6. Do you consider technology in the classroom as a necessity for learner achievement?
    - If yes how so, if not please clarify why not
7. Do you know how to adapt technologies in the classroom in a way that you enhance what you teach, how you teach and what students learn?
    - If yes how do you utilise the technologies
8. How long have you been teaching mathematics and which grades can you teach?
9. How do you decide which teaching method goes with a particular topic?
    - Do you change the teaching method depending on the content you are teaching?

- What decision do you go through when deciding which content goes with this teaching method, walk me through the process

10. Are you a mathematics teacher by profession?
    - Do you think technology is important in mathematics, is so why, if not why not?
    - What advantages do you think technology in mathematics possess for the learner?
11. Do you think that your lessons are enhanced by the integration of technology?
    - If yes please explain
    - If not, please explain
12. Can you describe how the learners are engaged when your lessons are supported by technology?
    - Do you feel technology makes learners more engaged in the learning process?

Appendix B: Observation schedule: Data collection instrument 2

Observation Schedule: This observation schedule was used to determine which aspect o the TPACK framework educators currently possessed. It was also use to gain first-hand experience on how the teachers integrated ET for pedagogy in mathematics classrooms in the Western Cape.

Teacher F	Teacher activity	Student activity
Component:		
Technological knowledge (TK)		
Pedagogical knowledge		
Content knowledge		
What ET are in the class?		
Is the teacher Digitally fluent		
Which technology is the teacher using?		
How does the teacher use ET in the lesson?		
Is the teacher in possession of TPACK?		
How is learning enhanced using technology?		
Which sections of the TPACK framework does the teacher need to improve on		

Appendix C: Cape Peninsula University of Technology: Research Ethics Clearance Certificate

Cape Peninsula University of Technology

***For office use only	
Date submitted	26 Jan 2018
Meeting date	5 Mar 2018
Approval	P/Y√/N
Ethical Clearance number	EFEC 7-5/2018

FACULTY OF EDUCATION

RESEARCH ETHICS CLEARANCE CERTIFICATE

This certificate is issued by the Education Faculty Ethics Committee (EFEC) at Cape Peninsula University of Technology to the applicant/s whose details appear below.

1. **Applicant and project details (Applicant to complete this section of the certificate and submit with application as a Word document)**

Name(s) of applicant(s):	**Addlight Ngonidzashe Buzuzi**	
Project/study Title:	Insight into mathematics teachers' adoption of technology for pedagogy in less affluent High Schools in the Western Cape	
Is this a staff research project, i.e. not for degree purposes?	N/A	
If for degree purposes the degree is indicated:	Master of Education (M Ed)	
If for degree purposes, the proposal has been approved by the FRC	Yes	
Funding sources:	Self	

2. **Remarks by Education Faculty Ethics Committee:**

This Master's research project is granted ethical clearance valid until 26 May 2020.		
Approved: Yes	**Referred back:**	**Approved subject to adaptations:**
Chairperson Name: Chiwimbiso M Kwenda **Chairperson Signature:**		**Date:** 27 May 2018
Approval Certificate/Reference: EFEC 7-5/2018		

EFEC Form V3_updated 2016

Appendix D: WCED research approval letter

Education

Audrey.wyngaard@westerncape.gov.za
tel: +27 021 467 9272
Fax: 0865902282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

REFERENCE: 20180425–1586
ENQUIRIES: Dr A T Wyngaard

Mr Addlight Buzuzi
306 6 th Avenue
Grassy Park
7941

Dear Mr Addlight Buzuzi

RESEARCH PROPOSAL: **INSIGHT INTO MATHEMATICS TEACHERS' ADOPTION OF TECHNOLOGY FOR PEDAGOGY IN LESS AFFLUENT HIGH SCHOOLS IN THE WESTERN CAPE**

Your application to conduct the above-mentioned research in schools in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners and schools should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' prograammes are not to be interrupted.
5. The Study is to be conducted from **02 May 2018 till 28 September 2018**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

    The Director: Research Services
    Western Cape Education Department
    Private Bag X9114
    CAPE TOWN
    8000

We wish you success in your research.

Kind regards.
Signed: Dr Audrey T Wyngaard
Directorate: Research
DATE: 25 April 2018

Appendix E: Permission letter from principal to conduct research at a school

Mr. Addlight Buzuzi

306 6th Avenue

Lotus River

7941

Cell no: 073 944 6585

Dear Mr/Mrs/MS

Permission to observe and interview your Teachers for my CPUT Master's thesis

I am currently affiliated with Cape Peninsula University of Technology where I am doing my Master's degree specializing in Mathematics. My research topic is:

"Mathematics teachers' adoption of technology for pedagogical use in less affluent High Schools in the Western Cape**".**

I would like to obtain your permission to observe and interview your teachers at a time that is convenient to them. My role will be to observe Mathematics classes and to interview teachers about their opinion on technology adoption in mathematics classrooms. I will not in any way disrupt their day to day duties.

I will require you and the educators, to sign this letter of consent which gives me your permission to continue with this research. My research plan is to observe and interview the teachers between the 17th of July 2018 and the 31st of August 2018.

All the information obtained from my observation and interviews will be kept strictly confidential and that the above arrangement can be terminated at any time. The research project, when completed, will be available for you to view. Please note that the names of the participants will be kept anonymous. Please feel free to contact me if you need any additional information regarding this research proposal.

Yours Sincerely

I Mr/Mrs/Ms……..give Addlight Buzuzi permission to observe and interview educators for his CPUT Master's thesis.